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A

HISTORY

OF

INFUSORIAL

ANIMALCULES,

LIVING AND FOSSIL:

ILLUSTRATED BY

SEVERAL HUNDRED MAGNIFIED REPRESENTATIONS.

BY ANDREW PRITCHARD, M.R.I.,

Author of the "Microscopic Illustrations," &c.

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PREFACE.

In presenting to the public a third volume on the *History of Infusorial Animalcules,* I venture to express a confident hope that it will prove as acceptable as the Editions of 1834 and 1841.

This Edition has been jointly prepared by J. T. Arlidge, M.B. and myself. In it the classification used by Ehrenberg in his great Work of 1838, has been retained; whilst abstracts of the systems proposed by other naturalists have been added and explained.

The great number of new genera and species (both living and fossil) here introduced, necessarily increased the bulk of the volume, which has been further augmented by doubling the number of Engravings—Graphic Illustrations being indispensable to a clear comprehension of the subject. These additions, however, have been made without increase of cost to the subscribers who have honoured me by their confidence.

I have freely availed myself of the elaborate works of Ehrenberg,—the splendid monographs of Kützing and Ralfs, as well as the valuable researches of Professors Bailey, Siebold, Dujardin, Dr. Stein, Mr. Brightwell, and others.

The original papers in the Annals of Natural History have also largely yielded materials. In all cases I have been careful to insert the authorities; and I hope that those who may hereafter quote from this volume will be equally just.

The aim has been to form as complete a manual as the present state of knowledge will admit; and I believe that it will be found useful, both to the Naturalist and to the Microscopic Observer.

Canonbury Lane,
London,
24th June, 1852.

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Abbreviations used in Part III.

Agh. for Professor Agardh, of Sweden.

B. for Professor Bailey, of New York

Brè for M. de Brèbesson, of Falaise, Normandy.

Duj. for M. Dujardin, a French naturalist.

E. or (Ehr.) for Professor Ehrenberg, of Berlin.

Kütz. or K. for Professor Kützing, author of several elaborate works.

M. for F. O. Müller, the author of the first systematic History of Animalcules.

R. for Mr. Ralfs, author of an elaborate monograph on Desmidieæ.

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PART I.

AN INTRODUCTORY HISTORY

OF

INFUSORIAL ANIMALCULES.

Among the arguments deducible from the natural world, in support of the existence and superintending providence of an Almighty Intelligence, none can carry a stronger conviction home to a reasoning and philosophic mind, than those drawn from that portion of it which falls under consideration in the present treatise. Distributed everywhere throughout this world, designed and formed by an all-wise and gracious Creator, serving, were it no other purpose, that of evidencing his all-pervading power, exists a race of beings so diminutive, as to have provoked man's utmost ingenuity to bring them within the range of his perceptive powers.

"In the clearest waters, and also in the troubled, strongly acid, and salt fluids of the various zones of the earth; in springs, rivers, lakes, and seas; in the internal moisture of living plants and animal bodies, and, at times, carried about in the vapour and dust of the whole atmosphere of the earth, exists a world, by the

common senses of mankind unperceived, of very minute living beings, which have been called, for the last seventy years, INFUSORIA. In the ordinary pursuits of life, this mysterious and infinite kingdom of living creatures is passed by without our knowledge of, or interest in, its wonders. But, to the quiet observer, how astonishing do these become, when he brings to his aid those optical contrivances by which his faculty of vision is so much strengthened. In every drop of stagnant water, we are generally, if not always, able to perceive, by means of the microscope, moving bodies, of from 1-1150th to 1-25,000th of an inch in diameter; and which often live packed together so closely, that the space between each individual scarcely equals that of their diameter."

The wisdom and goodness of providence have endowed these living creatures with all that can be needed for their happy existence. A reference to the drawings, generally, will afford some idea of their beautiful and varied forms. What, for instance, can be more admirable in structure than the Infusoria of the family *Volvocina?* (See *Plate* I. *figs.* 34 to 57.) In what class of animals are its members so curiously and so symmetrically associated together? In the *Volvocina*, innumerable beings are colonized within a simple, delicate, crystal-like shell, whose form, sometimes spherical, at others quadrangular, presents us with examples of perfect symmetry and proportion. Who can behold these hollow living globes, revolving and disporting themselves in their native element, with as much liberty and pleasure as the mightiest monster of the deep:—and, to carry our views a step further, to speak in detail of series of globes, one within another, alike inhabited, and their occupants alike participating in the same enjoyment—who can behold such evidences of creative wisdom, and not exclaim with the Psalmist, "How wonderful are thy works, O Lord, *sought out* of all them that have *pleasure therein!*"

Again, take an example from the *most minute* of living beings to which our knowledge at present extends, such as the *Monas crepusculum* (see Part III.), and compute the number which could occupy the bulk of a single grain of mustard seed, the diameter of which does not exceed the tenth of an inch: it is hardly conceivable that within that narrow space *eight millions* of active living creatures can

exist, all richly endowed with the organs and faculties (as hereinafter fully described) of animal life! Such, however, is the astonishing fact. Again, to take an example from those families of Infusoria, which possess the power of *changing their forms* at pleasure, and yet to confine it to the drawings of the first plate (although the second would furnish *protean* phenomena of a more extraordinary character), take the figures of the family *Astasiæa (groups* 68 to 82), and you have creatures capable of assuming all the various forms there depicted, in the short interval of a few seconds, and that under the observer's eye. In the beautiful little creatures of the genus *Euglena*, you may also perceive a distinct *visual organ*, by which they can steer their course with unerring rectitude. Many of the Infusoria do not possess this organ. But, mark the all-wise dispensation of Providence in this respect!—those which have it live, for the most part, near the surface of the water, whilst those which have it not, as the *Bacillaria*, locate near the bottom This circumstance in their economy has not hitherto been noticed.

Lastly,—still restricting our observations to the drawings of the first plate, look at the graceful forms of the *Closterina* (*fig.* 63 *to group* 67), which have long rivetted the attention of the most eminent naturalists of modern times, and which long defied all their powers of investigation, aided by all the refined and searching means which human ingenuity could supply, to determine whether they are animals or plants!

In short, there is not one species, out of the many hundred described in the third part of this work, but offers ample scope for the exercise of our deepest reflection, at the same time that it affords an admirable proof of the adaptation and design of Creative Wisdom.

The plan of this work will comprehend a description of those creatures which are generally to be found in animal or vegetable infusions, and such as agree with them in their general structure and habits. Special descriptions of each will be found in Part III.

In *Die Infusionsthierschen*, the author has occasionally introduced animals which have been classed under other divisions of the animal kingdom. As examples, we may take the family Dynobryonia, the members of which are classed as zoophites by other naturalists.

Again, in the genus Bodo, some of the species are proper Entozoa, and, therefore, ought to be excluded. Having, however, taken that work as the basis of my arrangement, all the species described therein will be found here.

With regard to the Spermatozoa of animals, our knowledge of them is but scanty and confused, arising principally from their extreme minuteness, which, even with the assistance of our most perfect microscopes, places them at the very limit of our vision. The great importance of this subject, especially to the medical professor, has obtained for it, from several distinguished naturalists, long and laborious researches; but, on the whole, the results have been contradictory (see section XVII.) It will be sufficient, therefore, to say, that since the time of their discovery (1676), up to the present period, all that we know of the *true* Spermatozoa of animals, is, that they are not distinguishable from Cercaria, found in the liver of snails, the animal organization of which has been made out by Bauer, Wagner, and Ehrenberg.

The recent discoveries of Dr. Unger on the Spermatozoa of plants is a subject of such deep interest, and so little known in this country, that I have introduced a description of them under the genus Spirillum; while original drawings of them will be found in *Plate* XII.

It has been said that the line of demarcation between many species of animals and plants—the transition from the one kingdom to the other—is not easily defined. Indeed, so close is the connection between them, that some members of the families Closterina, Vibrionia, and Bacillaria, which are considered by Ehrenberg to be animals, are, by many eminent botanists, set down as belonging to the vegetable kingdom, and classed with the minute aquatic algæ of the genera Oscillatoria, Spyrogyra, &c. The true species of the two genera just named, it must be admitted, are not of animal structure; and Dr. Ehrenberg has given us the following reasons why they are not included with the Infusoria:—1. They have no oral aperture. 2. They never propagate by direct self-division, but by the mere dissolution of the gemmæ. 3. They increase in size only by the growth of the gemmæ. 4. They have both the external and internal rigidity of vegetable organization. 5. The impregna-

tion of the Spyrogyra resembles that of some of the species of Fungi. 6. They develope acicular crystals within themselves, like some well-known plants. 7. Their motion is not perceptibly voluntary. (See section IV.)

For the convenience of reference, it is proposed to divide this part into sections; and, although the subjects treated of may not, as respects some of them, have received all that careful investigation which they deserve, yet it is presumed that sufficient has been done to lead the minds of the more curious inquirer to a further research. Previous to which, I present the reader with Professor Ehrenberg's summary of the subject:—

1. All the Infusoria are organized, and the greater part of them (probably all) are *highly* organized bodies.

2. The Infusoria constitute two very natural classes of animals, according to their structure, which classes admit of subdivision, upon the same principle.

3. The existence of the Infusoria in the four quarters of the globe, and the sea, is proved; as also that of individuals of the same species in the most opposite ends of the world.

4. The geographical distribution of the Infusoria upon the earth follows the laws observed regulating that of other natural bodies.

5. Most of the Infusoria are invisible to the naked eye; many are visible as moving points; and the size of the body does not exceed, in any case, the 1-12th of an inch.

6. The minute invisible Infusoria, in consequence of their immense and swarming numbers, colour large tracts of water with very remarkable hues.

7. They give rise to one kind of phosphorescence of the sea, though in themselves invisible.

8. They compose (though singly invisible) a sort of mould, through living in dense and crowded masses.

9. In a cubic inch of this mould, more than 41,000 millions of single animals exist, and constitute, most likely, the chief proportion of living bodies upon the face of the earth.

10. The Infusoria are the most reproductive of organized bodies.

11. From one of the known propagative modes of the Infusoria—that is, self-division—a continual destruction, beyond all idea, of the

individual, and a similar interminable preservation and extension of it, in air and water, ensues, which, poetically, borders upon eternal life and growth.

12. The copulation of gemmæ, which perhaps includes the hitherto unsolved poly-embryonate riddle of the seeds of all plants and vegetable formations, is solved in the family Closterina.

13. The Infusoria, in consequence of their siliceous shells, form indestructible earths, stone, and rocky masses.

14. With lime and soda we can prepare glass, and swimming bricks, out of invisible animalcules; use them as flints; probably prepare iron from them; and use the *mountain meal*, composed of them, as food in hunger.

15. The invisible Infusoria are sometimes hurtful, by causing the death of fish in ponds, deterioration of clear water, and boggy smells; but not, as has been supposed, in giving rise to malaria, plague, and other maladies.

16. The Infusoria appear to be (as far as is yet known) sleepless.

17. The Infusoria partly break up (zerfliessen) by egg laying, and thereby undergo, passively, various changes of form.

18. The Infusoria form invisible intestinal worms in many animals, and in man, even if the Spermatozoa are excluded from amongst them.

19. The microscopic Infusoria have, also, themselves, internal and external parasites.

20. The Infusoria possess a comparatively long life.

21. As the pollen of the Pine falls yearly from the clouds, in the form of *sulphur-rain*, so do the much smaller animalcules appear (from being passively elevated with the watery vapour) floating in a live state in the atmosphere, and sometimes, perhaps, mixed with the dust.

22. In general, the Infusoria maintain themselves pretty uniformly against all external influences, as do larger organized bodies. It is true that they sometimes consume strong poisons without *immediate injury*, but not without an after effect.

23. The weight of the invisible Infusoria, light as it is, is yet calculable, and the most gentle current of air or draught can play with their bodies as with the vapour of water.

24. The evident and great quickness of the motion of Infusoria, is reducible as follows: *Hydatina senta*, moves 1-12th of an inch in four seconds; *Monas punctum*, the same in forty-eight seconds; while *Navicula gracilis*, takes six-minutes twenty-four seconds to progress the same distance.

25. Linneus said, *omnis calx e vermibus*:—either to maintain or deny *omnis silex omne ferrumve vermibus*, would be, at the present moment, unjust.

26. The direct observations, as yet known, upon the theory of *generatio primitiva*, are wanting in necessary strictness. Those observers, who profess to have seen the sudden origin of the minutest Infusoria from elementary substances, have quite overlooked the compound structure of these organic bodies.

27. The frequent wonderful changes of form of many Infusoria are yet to have their limits, and the laws governing them defined.

28. The power of infusorial organization is instinctively shown by the strong chewing apparatus, with teeth, which they posses, and their exhibition, likewise, of a complete mental activity.

29. The study of the Infusoria has led to a more distinct and conclusive notion of animal organization generally, and the limits which circumscribe the animal form; from which all plants and minerals, that want the animal organic system, are strongly and distinctly separated.

30. Finally,—it results from these inquiries, that experience shows an unfathomableness of organic creations, when attention is directed to the smallest space, as it does of stars, when reverting to the most immense.

Section I.—*Localities and Appearance of Infusoria in Masses*.—In investigating most branches of practical science, especially those relating to Natural History, the subjects to which our observations are to be directed are generally difficult of attainment, and the inquiry cannot be prosecuted without considerable inconvenience. This, however, is not the case with respect to the *Infusorial Animalcules*. We can examine them in our chamber, at any leisure moment, and at any time or season, and we can procure them, at least the ordinary kinds, such as the *Paramecium*, *Kolpoda*, &c., with the utmost facility,—for they abound in most waters wherein the stalks

of flowers have been a few days steeped—whilst many of the more beautiful kinds, such as the *Volvocina, Astasiæa, Hydatinæa,* &c., are to be found in pools of clear standing water.

Many remarkable species, and some of the most elegant I have ever examined, have been taken in meadow-trenches, in the slowly running water, after a summer shower, and especially about the period that the first crop of hay was mown. Among healthy water plants, such as the Chara, Ceratophyllum, Conferv $\ae$, Lemna, &c., the various kinds of *Vorticellina* and *Rotatoria,* may be sought for with success. The stems of aquatic plants, particularly those of the description just mentioned, have often the appearance, to the naked eye, of being encased with mouldiness or *mucor,* which, on being examined under the microscope, proves to be an extensive colony of arborescent animalcules. Whenever this appearance is of a bluish milky hue, the species will mostly be those of the *Vorticella* or *Epistylis.* (See the *Engravings.*) If you observe little dark bristle-like bodies standing out among the stems, you may expect them to be the *Melicerta;* and the little yellow gelatinous balls upon the Ceratophyllum are, probably, the *Megalatrocha.* In clear shallow pools, the *Volvox globator* (*fig.* 55) may be met with in vast numbers in the spring of the year; and, when these are found amongst Lemna, by examining them under a deep magnifying power, you may often discover, within their hollow spheres, the *Notommata parasita,* like so many white specks. The dust-like stratum we frequently notice on the surface of stagnant ponds, is often composed almost entirely of species of the most beautiful colours, such as the *Euglena, Chlorogonium, Pandorina, Gonium,* and *Bursaria.* The thin shining film, which sometimes covers plants in pools of water, assuming the varied hues of red, brown, yellow, green, and blue, is also made up of Infusorial Animalcules. For example—those objects, which under water appear to be coated with a thick green matter, abound with the different species of the *Euastra* and *Closterium,* or with the *Arthrodesmus quadricaudatus* and *A. pectinatus,* the *Stentor polymorphus,* and *Vorticella chlorostigma;* and those objects which have a bright orange-coloured coating, derive it from the presence of the *Stentor aureus.*

The abode of animalcules is not, however, confined to the clear

fresh water of lakes, rivers, pools, springs, and trenches, but extends even to the briny ocean, to strong acids, tannin, and the fluids contained in the animal and vegetable creation. In moist earth, the species of *Bacillaria* and other shelled animalcules may also be found; and even the very air we breathe may teem with them and their germs, whilst the gentlest breeze will be sufficient to waft them in myriads over the distant waters, and to diffuse these living atoms over the face of Nature. So that, in short, whether we descend into the deepest mines, where darkness ever reigns, or climb the loftiest mountains, whose summits glow with almost perpetual sunshine, there shall we find them located alike.

Although the colouring of water is sometimes derived from the oxides of iron and other mineral or earthy substances, over which it flows, or from the Oscillatoria and other minute Algæ which it contains, an intensity of colouring will also be given it by the presence of Infusorial Animalcules. Thus the *Astasia* imparts a blood-red colour, as also the *Euglena ruber;* the *Gallionella, Navicula,* and *Gomphonema,* impart an ochreous hue. Blue proceeds from the *Stentor ceruleus.* Masses of water assume an intense green from *Monas bicolor, Uvella bodo, Glenomorum tingens, Phacelomonas pulvisculus, Cryptomonas glauca, Cryptoglena conica, Pandorina morum, Gonium pectorale, Chlamidomonas pulvisculus, Volvox globator, Astasia* and *Euglena sanguinea,* when young; *Euglena viridis, Chlorogonium euchlorum,* and *Ophrydium versatile;* yellow from the *Astasia flavicans;* a milky tint from the *Polytoma uvella,* and *Ophryoglena atra,* when they are numerous.

The rapid and mysterious transition of colour, occasionally observable in lakes, and which has often created an alarm in the timid minds of the superstitious inhabitants on their borders, the microscope has shewn to arise from certain changes in the condition of Infusoria. Thus, a lake of clear transparent water will assume a green colour in the course of a day; nay, more, it will become coloured and turbid in the middle of the day, when the sun brings these creatures to the surface, and rapidly developes them, or causes their dead bodies to ascend, whilst in the morning and evening, it will again be clear.

The phosphorescence of the sea appears to be occasioned, in many instances, by the presence of animalcules, which, although individually imperceptible, often render luminous many miles of water by the immensity of their numbers.

In the same manner, large arborescent figures, resembling Fuci and Algæ, are formed by the *Micromega;* and masses of great extent by *Epistylis* and *Schizonema.*

The Bacillaria or their shell-like siliceous coverings, (loricæ) are largely concerned in the formation of the earth's crust, entering extensively, sometimes, almost exclusively, into the structure of large sections of the earth's strata, especially those of the tertiary period. The character of the rock so constituted, will vary according to the nature of the associated earths, whether argillaceous, siliceous, or calcareous. Thus, we have evidence of the existence of Infusorial life in the earliest eras of the globe; and what is still more curious, we find species existing at those remote epochs, still represented in the existing fauna. Nor are instances of such enormous accumulations of these minute beings, as to build up land from the sea-bottom, wanting, even at the present day. For instance, we learn from Sir J. Ross, and other explorers of the Antarctic Ocean, that the water between the parallels of 60° and 80° south latitude, is of a pale ochrous brown colour from the enormous number of microscopic *Diatomacea*, and that the death and decomposition of these same beings produce a submarine deposit or bank of vast dimensions, occupying an area of 400 miles long by 120 wide, and flanking the whole length of Victoria Barrier.—(Dr. J. D. Hooker, *Report British Association*, 1847.)

Among other almost unlooked for localities of Infusoria are meteoric dust, and other similar substances, precipitated from the atmosphere. In such matters, Ehrenberg has discovered siliceous loricæ chiefly belonging to the family *Bacillaria* (Section XXVI.) together with the calcareous shells of the Phytolitharia. Volcanic ashes even furnish specimens of Infusoria, and the same great microscopist has also interpreted the nature of the marvellous blood-like spots, which, much to the horror of the ignorant and superstitious, have occasionally appeared suddenly on bread and other

farinaceous substances; he having shown that such stains are due to the astonishingly rapid development of a monad, therefore called the *Monas prodigiosa*.—(See *Berlin Transactions* for 1847).

We should not omit to mention a very common mistake with respect to seeking after Infusoria. Some persons imagine that if they procure a portion of fetid ditch water, or take a few flowers, and immerse them in a flower glass full of water, they will be furnished in a few days with all the varieties they may desire; the fact, however, is very different from this. It is true, that in such cases, Infusoria will be found, but they will be only of the most ordinary kinds. Those of high interest, either as regards their structure, form, or colour, like all the other master-works of Nature and of Nature's God, are not so easily attained. Some degree of skill must be exercised for the purpose. But as we shall fully explain this matter in the section on the method of procuring and selecting Infusoria, we need not proceed further with the subject here.

SECTION. II.—*General External Forms, Coverings, Organs, and Members of Infusoria.*—Before entering on the classification of Infusorial Animalcules, as determined by their *internal* structure, it will be well to make a few remarks upon their general appearance and *external* characters, as exhibited by the microscope. The forms and members of large animals may be said, in one respect, to differ but little from each other; the comparative anatomist being enabled to trace, by easy gradations, one common type throughout the whole, the varieties being occasioned by a greater development of certain parts, and the suppression of others. Such, however, is not the case with Infusoria. The general forms of Infusoria will be best conceived by a reference to the drawings, inasmuch as words would be found insufficient to convey an idea of the vast varieties which they assume. Some are egg-shaped; others resemble spheres; others, again, different kinds of fruit, eels, serpents, and many orders of the invertebrated animals, funnels, tops, cylinders, pitchers, wheels, flasks, &c., &c.

The covering, or outer tunic, of Infusoria, is of *two* kinds; the *one* soft and apparently membranous, yielding to the slightest pressure, and accommodating itself to the state of repletion or other-

wise of the animalcule, and thus resembling the tunic of the naked Mollusca and Annelida, as slugs, leeches, &c.; the *other*, stiff, rigid, and hard, having the appearance of a shell, though, from its flexibility and transparent nature, it is more like horn. The creatures possessing the former of these are termed the naked, shell-less, or *illoricated* Infusoria, whilst those invested with the latter constitute the *loricated*. I shall, therefore, adopt the terms *loricated* and *illoricated* in this work, because they appear to be the least objectionable; for, although, in etymological strictness, *lorica* simply means a shell, yet, as we commonly attach the idea of a certain composition to the word shell, it may be as well to avoid the use of it.

In the doubtful organisms which form the large family *Bacillaria*, the botanist employs the terms *frustule*, *froud*, and *valve* for the outer covering of those they consider vegetables. The reader will, therefore, bear in mind these several words, and is referred to the general remarks on that family and its sections given *in extenso* in Part III.

The *Lorica* differs greatly as to its composition in different genera. In some cases it is composed entirely of silica; in others, of lime, combined with carbonic acid as a carbonate, with a portion of the oxide of iron. In some, it is destructible by heat, in others, not so. There is a difference also as to the proportion of the creature enclosed within the lorica. Some Infusoria are entirely encased, as in a box or pitcher; whilst others are only so in part, having merely a shield or carapace over them. Where the lorica encloses the animal, save its head and tail, as does the covering of the tortoise, it is called a *testa* or *testula;* when it covers the back only, a *scutellium* or shield, as in *Euplotes*, *Aspidisca*, &c. The term *Urceolus* applies to a gelatinous membranous or more firm external investment, having a bell-glass, cylindrical or conical figure closed at the posterior, but open at the opposite extremity, whence the animal may protrude itself. This variety of lorica is met with in the genera *Difflugia*, *Dinobryon*, *Vaginicola*, and *Floscularia*. The appellation *Lacerna*, or mantle, is applied generally to the gelatinous external membrane of the bodies of Infusoria, increasing with their increase in size. Within this tunic the animal may reproduce itself, and, for a certain time, the parent and offspring possess it in common, but after a time the mantle ruptures and the young escape. Thus, at a certain period, the]

individual existence, and is transformed into a simple capsule. This organization is met with only in the *Polygastrica* and more particularly in the genera *Volvox, Eudorina, Pandorina,* and *Gonium.*

Where a lorica exists it may be made up of two or more separable segments, called valves, when of two, it is said to be bivalved; when of more multivalved. The valvular form of lorica is chiefly met with in the great family *Bacillaria,* and it is such lorica that more particularly present a sculptured surface, and have been employed by microscopists as tests (see family *Bacillaria,* Part III). Some lorica are also furnished with appendages, or processes, projecting in the form of spines or knobs from their surface.

As, in very minute genera, it is often difficult to ascertain, by mere inspection, whether they are enclosed within a lorica or not, it will not be deemed uninteresting to point out the manner in which this may be determined. Having obtained some specimens of the Infusoria, we will suppose of the family *Cryptomonas* (*figs.* 21 to 33), place a drop of water containing them in an aquatic live-box, compressor, or crush-box, mixing a little colouring matter with the water, according to the directions given in the section "*On feeding Animalcules with coloured Materials,*" when, if *loricated,* a clear transparent ring will be observed, encircling the animalcules, and keeping them separate from the fluid in which they are immersed. Should this test, however, be deemed unsatisfactory, press down the cover of the aquatic live-box, so as to crush the specimens, when the coloured fluid will enter and surround their bodies, and by a proper management of the illumination of the microscope, the broken edges of the lorica will be visible, as seen in *fig.* 33, which is a representation of the *Trachelomonas volvocina,* similarly circumstanced.

Until recently, many of the genera of the smaller kinds of animalcules were supposed to be devoid of any *external* organs whatever; but the feeding on coloured substances, and the introduction of achromatic glasses, have proved the incorrectness of this conclusion, even as respects the Monads. The simplest external member, observable in the Infusoria, is a single, delicate, hair-like filament, differing much in length, situate near the oral orifice or mouth, whence it has been designated the *proboscis.* When this member is of an uniform

appearance, it is said to be *filiform*, or thread-like; but, when it tapers toward the extremity, like an eye-lash, or cilium, it is called *flagelliform*. This organ is used by the animalcule both for locomotive and purveying purposes. When the creature is in rapid motion through the water, this instrument is seen to act as an oar or paddle, in facilitating a progressive movement, whilst, at the same time, a current is created in the direction of its mouth, providing for the prehension of food. This member is not easily seen, inasmuch as considerable skill in the use of the microscope is required to show it, nor will even that, in all cases, suffice. The employment of finely-divided indigo or carmine, and the use of stops or diaphragms under the object in the microscope, afford the surest proof of its existence. When, by these means, its action has been detected, allow the water to evaporate, and you may notice a streak or mark, as it dries, left upon the glass, thus giving conclusive evidence of the presence of this organ. Sometimes the mouth is furnished with two of these proboscides, or cilia, nearly of equal length with the body, as in the genus *Chlorogonium*.

When these cilia are disposed in clusters, as with some of the larger polygastric animalcules, their structure may be more correctly ascertained. In the family *Oxytrichina* (see *Engraving*), the different modifications of these filiform organs constitute excellent characteristics of the genera.

Cilia may be described as hairs seated apparently upon a bulb. They perform a rapid vibratory motion, the point of each describing a comparatively large circle, whilst the base merely turns round upon its articulating surface, or part of the bulb to which it is affixed. Ehrenberg is of opinion that there are two kinds of cilia, viz. *Cilia continua*, in which the bulb is a continuation, or merely enlarged termination of each cilium; and *Cilia articulata*, in which there is a joint or articulation of the cilium to the bulb. Examples of the former may be observed in the *Stylonychia mytilus;* and of the latter in the *Paramecium aurelia* (*fig.* 330). Cilia in their arrangement are either separate and independent, or combined, forming in the latter case the rotary organ of the *Rotatoria*. In the first or simple form which exists in *Polygastrica*, the cilia are usually set round the mouth,

or spread over the body generally, in which case they are often disposed in regular rows, as in *Paramecium*, *Ophryoglena*, and *Uroleptus*, (*vide figs.* 329-334).

It may be remarked here, that naturalists have been greatly divided in opinion with respect to the functions performed by the cilia, more especially those belonging to the *Rotatoria*. It has been contended by some, that these organs form the chief instrument for respiration; nor is it at all improbable that such is the case, as we find that similar ones are placed round the gills or beard of the oyster, muscle, &c., to produce currents in the water, and bring a fresh supply to the creatures. The disposition of the bundles or clusters of cilia in the *Rotatoria*, and their appearance when in motion, may be considered as one of the most interesting and curious spectacles in the animal creation. Their strong resemblance to toothed-wheels, and their seeming continual revolution, have been most fertile subjects for the exercise of the imagination; indeed, there are few, if any other phenomena, which can excite more astonishment in the beholder. Let the reader turn to the various plates representing the *Rotatoria*, and mark the great variety of design, and exquisite beauty of execution, there displayed in the forms and disposition of these wheel-like organs, and his mind can hardly be restrained from reverting, in the profoundest admiration, to that Divine Intelligence by which such wonders could alone have been called into existence.

Setæ, or *bristles*, are a kind of rigid hairs or cilia, used as organs for the support of the body, and for climbing, but without having the power of vibrating like real cilia. These organs are sometimes devoid of the thickened base or articulation, as in the genus *Actinophrys* (*fig.* 266); whilst others possess a true articulation, as exemplified in the posterior three of the *Stylonychia mytilus*. Some are (awl-shaped) *subulate;* others have a knob at the extremity, and hence termed *capitate.*

Styles are thick straight setæ, usually seated on the under side of the body, projecting backwards like the tail feathers of birds. These never vibrate; neither have they a bulbous base, nor are their extremities bent or hooked. They are used for the support of the body, and for climbing, and are capable of more extended motion than setæ.

Uncini are curved hook-like processes, like thick short hairs. They emanate from the under surface of the body, and in office resemble the feet of larger animals. These organs do not vibrate, have neither bulb nor articulation, but sometimes possess considerable latitude of motion, not serving however for locomotion, but only for prehension.

Variable processes are another description of external members, which perform the function of locomotion in a very complete manner. In the family *Amoebaea*, the animalcule appears to have the power of protruding, at pleasure, any portion of its body, to form these processes; a property which has not inaptly obtained for it the designation of *protean*. In the loricated family Arcellina, the variable processes are definite, the protrusion being restricted to those parts of the body which are situated about the opening in the shell, designed for that purpose. These processes, like the protean ones, are soft or membranous, and resemble, though on a small scale, those of the *Mollusca*, of which the horns of the common snail are a familiar example. The Infusoria, however, have a greater command than the snails, &c., over these processes, and a more extended action, in proportion to their size.

In the Infusoria of higher organization, such as the *Rotatoria*, there are definite processes, of a *toe* or *claw-like* description, which are mainly used as organs of attachment. These are generally at the extremity of a certain prolongation of the body, which may be designated a foot-like member. To the inexperienced observer, this process has generally been supposed to be the tail; but, not being placed dorsally, with respect to the discharging orifice, it must be considered as occupying the position of the foot. In these creatures, there is a large development also of those parts of the body to which the rotatory organs are attached; and, in the case were two only of these organs are seen, a projection may be noticed on each side of the anterior portion of the animalcule, which has been termed an *ear:* For example, see *fig*. 416.

Other appendages of *Rotatoria*, unconnected with locomotion, are *Horns (Cornicula) Cirrhi* and spines *(Calcares.)* The first occur as elongated, fleshy, and rather firm projecting points, covering either the entire body, as in *Philodina aculeata*, or only some portion of it,

as the so-called tail in the genera *Rotifer, actinurus,* &c. The second variety of processes are longer and stronger than bristles *(setæ)*, rather resembling the tentacles of *Entomostraca.* Ehrenberg has only instanced such in the genera *Triarthra.* The spur presents the form of a short retractile style projecting from the neck. The existence of sucking discs *(patella)*, at the end of the tails or foot-like organs of some Infusoria, as at the extremity of the stalks of *vorticellæ*, and also on the tails of some *Rotatoria*, has been observed by Ehrenberg.

SECTION III.—*Of the Eye Specks, or Visual Organs of Infusoria.*—Our knowledge of the existence of these organs is wholly attributable to the invention of the achromatic microscope. In F. O. Müller's work, which contains drawings of the larger number of the animalcules, lately figured by Ehrenberg, and several of them made with much exactness, though on a very small scale, there is not one of the Polygastrica represented as possessing a visual organ, and but one species of the *Rotatoria*, in which he considered the existence of it established. By referring to the engravings, however, it will be seen that nearly all the *Rotatoria* have eye-specks, and that many of the genera of the *Polygastrica* are also furnished with them. If no other proof than this could be obtained, therefore, of the existence of a nervous system in these animated atoms, this might still be taken as a sufficient evidence of the fact.

One of the smallest, and apparently the simplest of the genera of Infusoria, in which the eye is perceived, is *Microglena*, in which, as in the greater number of cases, the colour or pigment is *red.*

By taking a glance at the tabular distribution of the genera of each family, as given after the general remarks on each, in Part III., in this work. The reader will notice, at once, that numbers of the genera of the *Polygastrica* are furnished with one eye-speck; and, in some cases, which however are more rare, with two. (See Section XV.)

In the *Rotatoria*, the number and position of these organs may be regarded as excellent characteristics of the genera. In the greater proportion of these, the animalcules have two, and, in some instances, three eyes; whilst, in one genus, *Theorus*, as many as seven or eight have been distinctly recognized on each side of the head. When the

eye-specks are situated in front of the œsophageal bulb, to which the teeth are attached, they are termed *frontal eyes;* and when behind this bulb, *cervical eyes.* They are sometimes disposed in a line, side by side, as in *Triopthalmus;* at others arranged triangularly, as in *Eosphora;* in *Cycloglena* they form a circle, and in *Theorus* a cluster on each side.

Ehrenberg having discovered the existence of eyes under the form of red specks in *Rotatoria,* argued from analogy the visual character of the similarly coloured specks in the *Polygastrica.* Recent accurate observations made on the eye-specks of *Rotatoria* (see section XXIII), prove that they are distinctly defined, have an investing capsule, and, in the words of M. Valenciennes, (Sur les embranchments inférieurs des Annelides, Ann. des Sciences Nat. 1850), have a crystalline lens, and, consequently, the essential attributes of visual organs. On the contrary, owing to the extreme minuteness of the Polygastric Animalcules, all appearance of definite outline is wanting in the red specks of *Polygastrica,* and resemblances of them being found in the reproductive germs of Algæ, many observers do not admit the visual nature of these red specks.

Section IV.—*Distinction between Infusoria and other Minute Animals and Plants.*—In our present state of knowledge, with respect to organic bodies, there are many difficulties in the way of determining on such boundaries as may reduce them to well defined groups. Even the line of demarcation between animals and plants, which, at first sight, might be supposed to be so very broad and distinct, upon a more minute consideration, is not easily settled. Nor is this surprising, for if we turn to inorganic nature, we find the chemist is equally at a loss to separate the two grand classes into which he divides those bodies: namely,—metals and non-metallic substances. While, at starting, they offer no resemblance, yet, by slight gradations, the bodies of each division approach the other where characters are still wanting to distinguish them. As examples, we may take the metal Silicium, which is sometimes regarded as a non-metallic body; while, on the other side, Iodine and Bromine resemble metals. In the organic world, no difficulty is found in separating the mammals, birds, and fishes, from forest trees and flowering plants; but, as we descend in each kingdom, the lines of demarcation become less strong

and decisive, until at length no single character is sufficient to distinguish them. Thus, motion, digestive structure, composition, the products evolved, &c., taken singly, are of little avail in separating an animal from a vegetable organism. Recent researches have rather increased these difficulties. The fashion of the present day is to magnify the arguments in favour of vegetable life and physical motions, while those on the side of an animal existence, are slured over. It is, therefore, desirable to pause before offering an opinion, especially when every distinction hitherto proposed, is seen to vanish if rigorously tested. The organisms of a doubtful animal nature, are principally found in the families *Monadina, Vibrionia*, and *Bacillaria*, which are fully described in Part III.

1. *Motion.* This is an excellent animal character, where its voluntary and spontaneous nature can be clearly perceived, but in microscopic bodies, vision being obtained by one eye only, and that under unusual conditions, difficulties present themselves which do not occur in common vision. Again, the germs, or spores of minute Algæ, and other vegetable organisms, swim about in water until they find a proper place for attachment, when they grow as a plant; hence some naturalists have supposed that animal life is transformed into vegetable, as the name zoospores implies. (See Vibrionia). The mollecular motions of Dr. R. Browne—namely, those seen under a deep magnifier in a drop of water, in which finely divided gamboge or other organic substances have been triturated; these motions have been compared with the spermazoa of animals and plants, which are now considered as physical motions only. The circulation or cyclosis in plants, so well exhibited in the Chara, have been compared with the motions in the Closterina and Bacillaria (see Part III), and hence they are only allowed a vegetable life. (See M. Thuret on the Zoospores of Algæ, Ann. des Sciences Nat. 3ieme series Tom XIV., 1850.)

2. *Cilia.* The presence of these organs for locomotion, is a strong argument in favour of the animal nature of an organism, but alone are insufficient, as the minute spores of some Algæ possess them.

3. *Digestive Organs.* The presence of a stomach would strongly tend to the establishment of an animal, but plants have been discovered which possess a cavity for admitting water, and thus resembling a digestive sac in its simplest form. While if imbibition

by the cuticle be admitted, the cells of plants approximate very closely to animals. The difficulties, however, are greatest in the *Desmidiacea* and *Diamomacea,* to which the reader is referred to for particulars.

4. *Composition.* Tertiary compounds are claimed for the vegetable, but the Chlamidomonas, whose animal nature is undoubted, is only a tertiary compound. The presence of nitrogen was, sometime since, excluded from the vegetable, but it is now known that several plants contain azote.

5. *Starch.* The existence of the organic proximate element, Starch, has been much insisted upon as determining this question, indeed its almost constant presence in plants, renders it a desirable test; but, in the doubtful animal organism, their minuteness and the nature of their coverings, render it difficult of application; indeed, in those cases where it is most needed, as the *Desmidieæ* (which see) it too often gives equivalent results.

6. *The evolution of Carbonic Acid by Animals and of Oxygen by Plants*, has been proposed for determining this point, but the *Euglena viridis,* whose animal nature is admitted exhales oxygen, as do some of the doubtful family Bacillaria and the Volvox globator, the latter, however, has lately been claimed by the botanist.

7. *Visual Organs.* The existence of eyes would prove, beyond doubt, the animal nature of an organism; but the red points considered as eyes, which exist in many of the Polygastric Infusoria, are, by some naturalists, not admitted as eyes, similar red spots being observed in the spores of Algæ, are adduced as confirmatory of this position.

8. *Contractibility* has been proposed as a test. It applies only to the soft bodied forms, but M. Thuret says it is not peculiar to animals, but partaken also by the zoospores of Algæ.

9. *Multiplication by spontaneous division or fission.* This method of increase has been adduced by Ehrenberg, as evidence of the animal nature of the Bacillaria and other Infusoria, but, it is admitted, that the fissiparous division of vegetable cells is of a similar nature. (See Section XVI.)

10. The non-occurrence of development by conjugation, has been latterly insisted upon as separating animals from plants, but this distinction is now questioned. (See Desmedea, Part III.)

The action of acetic, acid and of electricity, on these minute organisms, have been proposed as tests, but hitherto the results have been unsatisfactory.

This uncertainty in distinguishing plants from animals, coupled with the observation of some peculiar phenomena in the production of spores in the lower Algæ, led those distinguished naturalists, Unger and Kützing, and others, to believe in the transition of some forms, from an animal to a vegetable existence, or *vice versa.* It seemed to Kützing, that there are beings in which animal and vegetable life are so intimately blended, that the kind of existence manifested, will depend on the predominance of one or of the other, and this too, without a necessary change of form. Unger goes further in his belief in the transformations of Algæ into animals, and the reverse; but, Siebold declares "such an opinion is unphilosophical; for, be the nature of any being what it may, vegetable or animal, we must consider it fixed and unchangeable. Moreover, the appearances on which Unger's views rested, are easily understood when we recognize the presence of cilia in both animals and plants, a fact, that naturalists overlooked. (Dissertatio de finibus inter regnum animale et vegetabile constituendis, Erlangæ 1844.")

M. Thuret says the error of believing in the metamorphosis of Algæ, has arisen from the confounding together aggregations of globules of similar appearance, but of very different nature,—as, Infusoria, Zoospores of Algæ, Spores of Mosses, Gonidia of Lichens, &c.; a confusion which has led some to suppose that an Algæ can produce not only another of a species or even germs different to itself; but also give origin to a Moss, Hepatica, or Lichen, according to the circumstances under which the germ was placed. "For my part, I never was witness of any such marvellous transformations. I have never seen a *Diselmis* produce an Algæ, nor an Algæ a true *Diselmis.* On the contrary, whenever I have had the opportunity of following, for a sufficiently long time, the germination of a zoospore, I have seen produced, not an Algæ of another species, still less a Moss or a Linchen, but an individual evidently belonging to the same species as the parent plant."

At another place he writes, "the germination or extension of the zoospore into a tissue similar to that of the parent plant, appears to me a good character to distinguish those bodies from Infusoria. Still one cannot discover in this phenomenon the basis of a division between the lower forms of the two kingdoms; for vegetables occupying the lowest grade in the series of Algæ—ex. the Nostoclimeæ, Palmelleæ, &c., seem to have no other mode of reproduction than spontaneous division analagous to that of the most simple animals."

SECTION V. *Effects of Temperature on Infusoria.*—As vitality in these creatures is not destroyed by the ordinary cold of winter, most of the common Polygastrica may be found at that season in ponds under the ice. The *Vorticella microstoma* will live after being exposed to 8° of Fah., and the ice gradually thawed; although the number in this case may not exceed one in a hundred. Below this temperature they will not survive. The same may be said of the *Monas termo* and *M. spirillum*, the *Paramecium aurelia*, *Cyclidium glaucoma*, *Glaucoma scintillans*, and *Kolpoda cucullus*. When Infusoria are destroyed by the cold, no rupture or injury will be apparent on their bodies, excepting with the *Chilodon cucullus*, and some few others, which, under these circumstances, will often become dissipated. The *Stentor polymorphus* and *Mulleri* will not live many hours in a temperature of 9° Fah.; and arborescent *Vorticella*, when subjected to that degree of cold, fall from the stalks and die.

The Rotatorial animalcules cannot endure such low temperatures as those above named.

When a small quantity of water, having animalcules in it, becomes frozen, and is placed under a microscope, in a cold situation, Ehrenberg states that if the ice be clear, each animalcule or group will evidently be surrounded by an exceedingly small portion of water, which that naturalist supposes to be occasioned by the superior temperature or animal heat of the creatures preventing congelation; and he is of opinion, that in all cases where this portion of the water freezes, the animalcule necessarily dies.

If the water containing polygastric Infusoria be gradually raised to a temperature of even 125° of Fah., these creatures will live; and Dr. E. observes, that some of the *Chlamidomonas pulvisculus*

existed, on one occasion, in water at 200° of Fah. If the increase of temperature be sudden, the animalcules die at 140°, notwithstanding it be kept up for only half a minute.

Some animalcules, however, discover an appropriate habital in hot springs, and to such, consequently, we may suppose a high temperature necessary.

M. Doyère, by numerous experiments made with *Rotatoria, Tardigrada*, and *Anguillulæ*, has proved that those animals when put into hot water at 212° Fah. were killed outright, but they retained the power of revival, when the water was at 113° to 118°. When dried, individuals were subjected to a heat of 216°, 252°, and even 261°, some were found which were capable of being revived.

Some *Vibriones*, which Focke discovered in milk, when frozen and again thawed, continued to live, and even when they had been dried for three weeks, revived on being moistened.

Focke has mentioned that *Pandorina morum*, and other proboscidated monads, appear to change very much in colour according to temperature and season. (See Reports Zoology: Ray Society, 1841).

SECTION VI.—*Effects of Air, Chemical Mixtures, and Poisons on Infusoria.*—That animalcules, like every other part of the animal creation, continually require fresh supplies of atmospheric air for their support, may be deduced from a variety of experiments. If a thin pellicle of oil be spread over the surface of the water in which they are contained, they very soon die from exhaustion; and, indeed, it must have often happened to those who are in the habit of collecting Infusoria, that when the cork has been left, by accident, too long in a phial full of water, they have experienced this mishap. This is especially the case with respect to the large *Rotatoria:* whenever experiments have been made with these creatures under an exhausted receiver, the result has invariably been that vitality ceases soon after the air has been expelled. Ehrenberg states, that they exist much longer in an atmosphere of nitrogen than in carbonic acid or hydrogen. The vapour of sulphur soon puts a period to their existence.

Poisons, which only mix *mechanically* with water, do not appear to affect them materially, but those which are soluble, or combine *chemically* with it, speedily destroy their lives. Many of the Infu-

soria can accommodate themselves to different fluids, provided that the transition be not too sudden. Thus, similar species may be found in rivers, at their source, where the water is perfectly fresh, and at their very mouths, or junction with the salt water of the ocean. *Hydatinea* have been fed upon powdered rhubarb without being sensibly affected by it; nor does calomel or corrosive sublimate kill them; at least they live some time after these have been mixed with the water. Strychnia causes instant death.

Mr. Addison states that liquor potassæ, produces on the smaller forms of the Polygastric animals, "the same effect as it does on the colourless blood and pus-corpuscles of mammalia; it penetrates the transparent integument of the animalcule by imbibition, and causes it to burst open and discharge its contents, which have the same appearance as the molecules and granules, from the colourless blood and pus-corpuscles.

In the larger forms of the polygastric animalcules, the large vesicles or cells (called stomachs) very visible in their interior, are all discharged from the bodies of the creatures in the same way, when submitted to the action of liquor potassæ. These so-called stomachs may be seen enlarging in the interior of the animalcule, prior to the rupture of the external integument; and when they are discharged from the body of the animalcule, numerous minute molecules may be noticed within them.

If the *Paramecium aurelia* be subjected to the action of a dilute solution of the alkali, in the proportion of half a drachm (Brandish's solution) to an ounce and a half or two ounces of water, it immediately commences a laboured rotatory wriggling motion through the liquid, and in many of the individuals, two remarkable vesicles will be seen tensely distended in the interior of the animalcule, very frequently accompanied with three, four, or five, perfectly transparent large circular globules, projecting from the body of the creature. After a short period the contents of the body may be seen discharging themselves into one or more of these transparent projections, while the body itself, or rather the integument of the body, may be seen to shrivel up, the motionless cilia fringing its circumference remaining very visible." (On the sacculi of the Polygastrica, Annals of Natural History, vol. 12, 1843, p. 101.)

These facts have been urged against the animal nature of the polygastric Infusoria, but, in fairness, it amounts to very little, as it is well known that some species of Acari will live in strong acetic acid, and spiders have fed upon sulphate of zinc, therefore, if the argument is worth anything, spiders and acari are plants, which is absurd.

Inferences drawn from the habits of the higher animals should be made with great caution, as the differences between them and microscopic organisms are so great.

SECTION VII.—*Effects of Electricity, Galvanism, and Magnetism, on Infusoria.*—All the experiments on record, which have been made upon animalcules with these powerful agents, appear to me to have been conducted without a due regard having been paid to their diminutive size; and hence, as might be expected, the results have proved fatal to their existence. We have, therefore, yet to learn what effects might be produced under proper modifications. To render this proposition more intelligible, suppose, for instance, that we wished to ascertain the temperature in which fish would live, we should not expect to arrive at the desired information by plunging them suddenly into boiling water. Dr. E. has remarked that a shock from a leyden jar, charged with twenty sparks from an Electrophorus, having a resinous plate seven and a half inches square, and a collector five and a half inches, suddenly killed the *Volvox globator*, *Stentor niger* and *S. aureus*, *Ampileptus moniliger*, *Chalimidomonas* and *Euglena viridis*. The bodies of the *Ophryoglena atra* and *Stentor polymorphus* were entirely dissipated by it, and also those of the *Epistylis flavicans*, after having been first thrown from their stalks. It generally required two such shocks to kill the *Paramecium aurelia*. When the electrical current passes near, and not through them, their movements appear to be unsteady, in the same manner as when the mental faculties in the larger animals are disturbed. Electricity, slowly produced, has a more powerful effect than when it is accompanied with rapid sparks. If water, containing animalcules, be placed between the poles of a galvanic battery, so as to be decomposed, of course, the creatures die; and a like termination will be occasioned by magnetic currents.

SECTION VIII.—*On the Resuscitation of Infusoria.*—In almost all

ages of the world there has been evinced a restless desire within us to pry into the nature or principle of *life,* and the precise conditions on which it is retained; and, notwithstanding that our bodies, its present *abiding place,* are confessedly frail and perishable, the unravelling of an invisible and immaterial agent has been sought for by a reference to them. Hence, each succeeding generation has occupied itself in proving the fallacy of preceding theories on this mysterious subject, and in forming new ones of its own. Even in modern times we have been told that dead matter, under certain circumstances, becomes spontaneously alive, as, for instance, horse-hair under water, &c. Too true it is, however, that, let our researches be what they may, unless our views are directed upwards to a higher principle than anything that we can argue upon, in what we see around us, our labours must end in nought but "vanity and vexation of spirit."

What, perhaps, has tended to awaken our inquisitiveness on this subject, more than anything else, has been that death-like condition of torpor, or suspended animation, in which human beings and other animals have been known to remain for a great length of time, during which the body is motionless, and apparently unsustained by any nourishment whatever. In 1701, Leüwenhoek observed this phenomenon in the Rotatorial Infusoria; and to such an extent did his observations lead him, that he declares they were capable of being removed from their native element, *dried* and preserved in this condition for months, and even years, and then resuscitated on being again moistened with water. That *Rotatoria* will revive, after remaining a day or two, apparently in a dry state, I have particularly mentioned in the *Natural History of Animalcules.* The distinguished author of *Die Infusionstierchen,* after many illustrations and comparisons made with reference to this subject, affirms, that wherever these creatures are completely dessicated, life can never again be restored. In this respect, they exactly correspond with animals of a larger kind; like them, for a time, they may continue in a lethargic and motionless condition, but, as it is well known, there will be going on, within them, a consumption, or wasting away of the body, equivalent to so much outward nourishment as would be needed for the sustentation of life.

In some recent experiments, Ehrenberg has observed, that living siliceous Infusoria form a sort of moist earth, (humus) and need a very small quantity of water to sustain life; and that even when such humus was let dry fifteen days, a great number still remained alive, and became very active on being introduced into a drop of water. If the earth was perfectly dried, they died outright, becoming incapable of revivification.

According to M. Doyère's experiments (Ray Society, 1841) *Rotatoria* may be completely dried in pure sand, in the open air, in dry air, and in a vacuum, without losing the capability of being revived by moisture.

Section IX.—*On the Supposed Method of Manufacturing Infusoria.*—Within the last few years an idea has been prevalent, and many persons have occupied themselves in endeavouring to realize so extraordinary a discovery, that animal life may be produced by means of galvanism. The creatures said to have been thus brought into existence, that have come under my observation, were neither the most minute, nor the most simple, in organization; and evidently belonged to the class Acari. That many scientific men should be more than sceptical upon this point, cannot be wondered at; and were it not that the notion originated with, and the experiments have been conducted by, one who holds a most honourable position amongst us, it would not have been entertained for a moment. That some mistake exists with respect to communicating vitality to matter, by this means, there cannot be a doubt.

It is not surprising that Linneus, with the imperfect microscopes of his day, should mistake Infusorial Animalcules for minute drops of oil in the water; but that Dutrochet, so late as 1833, should publish to the world that all the globular and elliptical Infusoria were vesicles set in motion by streams of electricity, and therefore could be artificially produced, is but another exemplification of the fact, that men of the most distinguished talents in one department of science may form very erroneous notions on others, especially where long continued observations, and very accurate perceptions, are indispensable for arriving at right conclusions respecting them.

In 1834, Cagniard Latour made a public declaration, that he had manufactured animalcules by the aid of carburetted hydrogen. This

assertion led to an examination, subsequently, of the creatures, by M. Audouin, who ascertained them to be a species of the Entomostraca, and who did not hesitate to pronounce the method, by which they were said to have been produced, to be fallacious.

The most ingenious experiment on the imaginary production of Infusoria, is that of Professor Bonsdorff, which he communicated to the German Naturalists' Association in 1834. The following is Ehrenberg's account of it:—" If a solution of chloride of aluminum be dropped into a solution of potassa, by the attenuate precipitation and solution of the aluminum in the excess of alkali, an appearance will be given to the drop of aluminated matter, by the chemical changes and reactions which take place, as if the *Amoeba diffluens* (see description, Part III.) were actually present, both as to its form and evolutions, and it will seem to be alive. Such appearance is considered, by its able discoverer, as bearing the same relationship to the real animalcule, as a doll or a figure, moved by mechanism, does to a living child."

Section X.—*On the Evolution of Light by Infusoria.*—Several small animals are known to emit light, apparently phosphorescent, as the female glow-worm, and some species of the *Myriapoda*, which I have frequently noticed in the gravel walks of a garden, on a dark autumnal evening. This emission of light, whether in the above-named animals, or in Infusoria, is evidently the result of a vital process. In the latter class of creatures, it seems like a single spark, of a moment's duration, but capable of being repeated at short intervals. That this light is electrical, analogy would lead us to infer; as experiments made upon larger creatures have proved it to be such with them.

The phosphorescence of the sea is not unfrequently due, in a great measure, to Infusoria, chiefly belonging to the family *Cyclidina;* and when we take into consideration the minuteness of these creatures, the largest not exceeding the 100th part of an inch, whilst some of them are scarcely one-twelfth of that size, our ideas of computation are too limited to form any just notion of the number which sometimes illuminates many miles in extent of the ocean's surface.

Ehrenberg found, at Wismar on the Baltic, that the *Peridinium tripos* and *P. fuscus* belonged to the phosphorescent Infusoria, and

further, that the emission of light was restricted to some only of these. Those individuals which were not phosphorescent were quite clear, whilst those which emitted light were filled with yellowish brown matter, which he considered to be developed ovaries, so that here also the development of light would appear connected with that of the ova.

In his paper *on the Infusoria of the Chalk,* (1840), that observer also stated that one of the most remarkable facts elicited in the course of his examination of the sea water, whilst in a state of phosphorescence, was, the presence of several species of two genera, the members of which have siliceous loricæ, which are abundant, not only in the chalk marls of Caltanisetta, Sicily, Oran, Zante, and Greece, but are those forms which, from the incalculable number of their very minute loricæ, compose the chief portion of the marls, which depend for their origin on the remains of species of Infusoria; and further, that they belong to genera, species of which had not then been seen in the living state.

SECTION XI.—*Classification of Infusoria.*—Among the various arrangements proposed for the distribution of animalcules by different naturalists—and we have not a few, as the minuteness of these creatures, and the imperfections of our microscopes, until lately, allowed ample field for the imagination to run wild—two appear to me to merit particular notice, and these, it is worthy of remark, are the productions of men who have laboured for years in making actual observations on them. The first is by O. F. Müller, whose posthumous work, entitled *Animalcula Infusoria Fluviatilia et Marina,* appeared in the year 1786. On this arrangement is founded my *Natural History of Animalcules,* prepared in 1832; between these two periods the additions to this branch of natural history, from actual observation, was not very great; indeed, until the latter work appeared, this subject could not be said to have assumed a definite character, and was unknown to the English reader.

The laborious and long-continued observations of Prof. Ehrenberg, in Germany, have enabled him, after several revisions and amendments, to present us with a classification, which, in my opinion, will remain as long our standard, on this subject, as that of Müller has been. It is curious, however, to observe, that in all the publica-

tions, up to the present day (in England at least), professing to give on account of Dr. E.'s classification, his older, and I may say, abandoned systems, have alone been presented.

Ehrenberg, in his great work entitled *Die Infusionsthierchen*, has not devoted much space in defining the Infusoria, or in giving a general view of the subject; but he commences almost immediately with their systematic arrangement; hence the Third Part of this work will give the reader some idea of the general character of that splendid volume; though the design of the two differing, namely, the latter being a work of reference, this a manual, many alterations, omissions, and additions have been made, especially in the present edition; hence it will be alike unjust to that distinguished naturalist, as to myself, to consider the one a mere abstract of the other.

Should the reader possess a copy of my first distinct work on this subject—the *Natural History of Animalcules*, and will make a general comparison between the system adopted in that work, and that in the present, he cannot fail to observe that, although the principles of classification of Müller and Ehrenberg are widely different, yet many of the groups occupy similar positions in the two systems. This coincidence is especially striking in the case of the *Vibrio* of Müller and the *Bacillaria* of Ehrenberg, and also between the commencing and concluding genera in each arrangement.

To proceed: Professor Ehrenberg divides the Infusoria into two grand classes—the *Polygastrica* and the *Rotatoria:* the former so-called by reason of the function of digestion, being carried on by numerous globular vesicles, or stomachs, whilst the latter, like most higher animals, have only one stomach.

Each class is again subdivided into families and genera, which are presented in a tabular form; and further details concerning the grouping of the *Polygastrica*, by Ehrenberg, are given in the section devoted to the consideration of their classification.

Based as the system of Ehrenberg is, on a particular hypothesis of the organization of Infusoria, of course it can be accepted only by those who subscribe to that hypothesis. Hence Siebold, Dujardin, and others, who cannot accept the polygastric structure as a fact, seek for some arrangement in accordance with their own views of animalcular organization (see Section XIII.)

One great change agreed upon by those who dissent from the Berlin Professor, is the exclusion of the *Desimidieæ* and *Diatomeæ* from the true animalcules, and the elevation of the *Rotatoria* to a position in the animal scale much higher than the so-called *Polygastrica,* with which their elaborate organization forbids their association under the common name of Infusoria.

In the classification appended, proposed by Siebold (Section XVII.) it will be seen that the term Infusoria is restricted to animals evidently moved by cilia, whereby not only the *Bacillaria,* but also those animalcules moving by variable processes under the title of *Rhizopodes,* are separated from Infusoria. In Dujardin's system, the *Rhizopoda* are, however, classed with Infusoria.

Section XII.—*Of the Polygastrica, as a class, and of their habitats and movements.*—Though some portions of the system of classification devised by Ehrenberg are certainly objectionable, I still feel that an arrangement is yet to be discovered that will supersede it.

In the opinion of the great Berlin naturalist, the *Polygastrica* constitute a natural group of animals, and are as satisfactorily distinguished as any other class. In this view, no other naturalist entirely coincides: almost all exclude the *Bacillaria* and *Closterina* (*i. e.* the *Diatomeæ* and *Desmidieæ*) from the *Polygastrica;* many go still further, and declare this class to be a collection of heterogeneous beings, many of which do not even belong to the animal kingdom. Thus, M. Agassiz says (Annals of Natural History, vol vi, 1850, p. 156), "Recent investigations, upon the so-called *Anentera,* have satisfactorily shown, in my opinion and in that of most competent observers, that this type of Ehrenberg's *Polygastrica,* without gastric cavities, and without an alimentary tube, are really plants belonging to the order of Algæ in the widest extension of this group; while most of the monad tribe are merely moveable germs of various kinds of other Algæ. As for the *Enterodela* ...... most of them, far from being perfect animals, are only germs in an early stage of development. The family of *Vorticella* exhibits so close a relation with the *Bryozoa* (cilio brachiate polypes), and especially with the genus *Pedicellina,* that I have no doubt that wherever *Bryozoa* should be placed, *Vorticella* should follow, and be ranked in the same division with them.

The last group of Infusoria, *Bursaria, Paramecium,* and the like,

are, as I have satisfied myself by direct investigation, germs of fresh water worms, some of which I have seen hatched from eggs of *Planaria* laid under my eyes." Mr. Girard coincides with Agassiz in these statements, and adds that the *Kolpoda cucullus* is one of the embryonic stages of a species of freshwater *Planaria*. (Proceedings of American Association, 1848, p. 402).

None of the *Polygastrica* exceed in dimensions the 12th of an inch, and some of the smaller species, as those of *Monas*, *Bodo*, *Bacterium*, and *Vibrio*, even when full grown, are but the 1-2000th part of that measure; indeed, so minute must be many of the young of these Infusoria, that they cannot be recognized by our microscopes. The genera *Stentor* and *Spirostomum* on the other hand, contain species as large as the greater wheel animalcules (Rotatoria), and are easily detected by the naked eye. Again, others, individually so small as to be almost invisible, form, when aggregated, green, red, yellow, blue, brown, and black-coloured masses of great extent. Thus, the clusters of some species in the families *Vorticella* and *Bacillaria* increase to such an extent that they attain a size of several inches, resembling Polypi.

The greater number of animalcules belonging to this class are found in fresh water; numbers inhabit the salt water of the ocean; and some live in astringent solutions, even those containing much tannin. They also exist in fluids produced by animal secretions; moist earth, too, is another situation in which some are to be found. As an instance of the later habitat, there has been recently found some earth near Newcastle almost entirely composed of living species of the genus *Bacillaria*, and other loricated Infusoria. Various kinds reside in the vapour of the atmosphere, in which, from their light weight, they rise in countless multitudes, and are blown about by the wind in invisible cloud-like masses.

The degree of motion possessed by the several genera of *Polygastrica*, varies greatly, whilst the sort of movement is as various. In several instances these peculiarities in locomotion are useful in characterizing genera; such will be found particularly indicated in the third or systematic part of this work. Some genera are attached, and still enjoy some extent of relative movement, such are *Vorticella*, *Zoothamnium*, and *Synedra*. Most of those unattached are, more or

less locomotive; but, especially in the family *Bacillaria*, there are many motionless genera. In *Volvox* we see a rolling motion, often very lively; in *Bodo* and *Coleps* a leaping movement, very active; in *Amœba* and *Difflugia*, a crawling, most nearly resembling that of snails; in *Stylonychia*, *Euplotes*, and *Himantophorus*, a creeping, by means of uncini, or bristle-like cilia, like that of insects; whilst in very many there is a simple gliding or swimming motion, in some, accompanied by rotation on their axis, and in others, of greater relative length, by writhing or serpentine movements; these last varieties are illustrated in *Paramecium*, *Uroleptus*, *Trachelocerca*, *Lacrymaria*. *Leucophrys*, *Stentor*, *Spirostomum*, &c. In very minute forms, as the *Vibrionia*, their movements are visible, as scintillations in the containing fluid.

Generally speaking, in all the *Polygastrica*, with the exception of the *Pseudopoda*,—those with soft '*variable processes*,' and the *Closterina* and *Bacillaria* (*Desmidieæ* and *Diatomeæ*), the property of movement is conferred by cilia, or by varieties of them called proboscides, or by stiff processes—uncini, &c (see Section II.) but in none are found true jointed locomotive members.

Prof. Owen remarks, in his Lectures on the Comparative Anatomy and Physiology of the Invertebrated Animals, 1843, p. 19, "If you watch the motions of the Polygastric Infusoria, you will perceive that they avoid obstacles to their progress; rarely jostle one another; yet it is difficult to detect any definite cause or object of their movements." Further on, he writes: "The motions of the *Polygastrica* have appeared to me, long watching them for indications of volition, to be in general of the nature of respiratory acts, rather than attempts to obtain food or avoid danger. Very seldom can they be construed as voluntary, but seem rather to be automatic; governed by the influence of stimuli within or without the body, not felt, but reflected upon the contractile fibre; and, therefore, are motions which never tire. We may thus explain the fact which Ehrenberg relates —not without an expression of surprise—namely, that at whatever period of the night he examined the living Infusoria, he invariably found them moving as actively as in the day time; in short, it seemed to him that these little beings never slept."

The power of locomotion may be for a time possessed by Infusoria,

which, as a rule, are attached; for example, *Stentor* and *Vorticella*, as also many of the doubtful Infusoria — the *Bacillaria*, which, becoming free, enjoy a slow swimming movement. Perhaps the most interesting example of movement by contractility, is that seen in the stalk or pedicle of the genus *Vorticella*, in which its activity is so great, and its character so peculiar, that it leaves no doubt of the presence of muscular fibre and muscular irritability.

The circular arrangement of very distinct cilia about the upper end—head and mouth, in *Vorticella*, *Stentor*, &c., and the whirling, wheel-like motion of those cilia, would seem, as Prof. Owen remarks, "to indicate the passage to the higher or rotiferous group."

SECTION XIII. *On the Digestive System of the Polygastrica.*—The microscopic observer, having procured a number of animalcules, will not fail to observe within the interior of many a number of circular spots; these are often very large in proportion to the size of the creature, and if the water is clear, they appear more transparent than the other parts of the animalcule. These vesicles the reader may readily distinguish in many of the drawings contained in the first six plates, and part of the seventh, which represent animals of the class *Polygastrica*. Like any other division of natural bodies, some of the members composing it, exhibit the essential characteristics of the class more prominently than others,—thus the genera *Kolpoda* and *Paramecium* contain the largest forms in which these vesicles exist. The reader will do well to refer to the drawings of these genera, which he can readily do by means of the *List of figures* at the end of the volume.

The older naturalists considered these vesicles as the ova; and Baron Gleichen made many experiments to endeavour to see their expulsion, but without success. This idea of the Baron's, respecting the nature of these bodies is the more remarkable, as it is to him we owe the original experiments of feeding animalcules with coloured food; and the fact of these parts becoming immediately coloured, while the surrounding portions remain transparent, could scarcely have escaped his notice.

From the observations of Dr. E., these globular vesicles appear to be distinct stomachs, of which a single animalcule belonging to this class possesses many, as noticed in another place. When one of

these stomach-cells, or sacs, has been filled with coloured food, and its situation carefully noted, in a short time the coloured spot will have changed its locality, and hence some naturalists will not admit of separate and distinct sacs or cavities, but maintain that the interior of the creature is one large digestive cavity, and that the globular mass of coloured particles has merely changed its position. To this objection, Dr. E. remarks, that he has distinctly observed a sac to fill, and then the particles to pass singly into another, and so on, until the nutritive portions having been imbibed by each cell in succession, the refuse is expelled by the animalcule. That few observers have noticed this process, is not remarkable, as it requires stedfast and incessant observation of a particular animalcule for some time, while a contraction of them, or a turning upon their axis, may mislead, or even a slight pressure or other injury loosening these cells, may occasion a voluntary change of place. Another objection to their being separate sacs or cells for the purpose of digestion is, that observers have not seen the canal or tube connecting them together; this Dr. E. admits is the case in many species, owing to its extreme tenuity. Also, that from its peculiar office, namely, the transmission of the food from one cell to another only, like the œsophagus in large animals, the tube possesses a contractile action, so that the difficulty of detection is augmented. Dr. E. affirms he has distinctly seen their canals while the food has been passing from one stomach cell to another; and in all his works, except *Die Infusionthierchen*, has presented us with drawings of them, and the manner in which they connect all the cells together. For observations of this kind, it will be advisable to select a large specimen of either of the following species:—*Chilodon cucullus, Trachelius Ovum, Vorticella chlorostigma*, or *V. convallaria, Opercularia articulata*, or *Stylonychia Mytilus*.

Again, the position of the discharging orifice has favoured the erroneous supposition of the excluded substance being ova, for this orifice is not situated in any certain relation to the mouth; for sometimes one orifice is common to both purposes, as in the fresh water Polype, and some other large creatures. In other *Polygastrica*, it is either situated anteriorly, posteriorly, or laterally, and this again may be either on the superior or inferior side. On this character,

Dr. E. has founded the subdivision of the class into families, as given in Part III. of this work.

Anxious to lay before the reader an impartial statement of this question, I shall, before proceeding with any general remarks on the *Polygastrica,* introduce here translations of the observations of a most distinguished German botanist, and likewise those of a celebrated French naturalist, while those of other naturalists relating to particular families, are inserted under those divisions.

Prof. F. J. Meyen writes :—" All naturalists are aware that Gleichen, in 1781, tried to make certain Infusoria eat carmine, and observed next day that they had several large red granules in the interior of their bodies. He thence concluded that they had swallowed the colouring matter. He likewise noticed that these coloured granules afterwards made their escape by another opening. Gleichen has figured these red granules very accurately; each of them is in the centre of a particular circle, the nature of which he does not explain. At a later period, M. Ehrenberg made the same remark, and he thence concludes that the Infusoria have several stomachs, which, in one section, are destitute of an intestinal canal, while in others they not only possess canals, by which they communicate with each other, but lateral appendages, which besides terminate in a coceum. In consequence of these discoveries, these Infusoria were designated by the name of *Polygastric* animals. M Ehrenberg believes that he has proved that their stomachs are filled one after another, and he has figured, more or less completely, the intestines which form the communication between the different stomachs.

"Many observers have already questioned these assertions of M. Ehrenberg (see the memoir of M. Dujardin, on this subject, in the tenth volume of the *Annales des Sciences Naturelles*). For my own part, I never admitted them, because, in the first place, I never could see the intestines which form the communication between the stomachs, and likewise because I have observed, many years since, that these supposed stomachs were moving in the interior of the body of many species with great rapidity, in the same manner as the granules which circulate in the joints of the Chara. I have often seen *Vorticella* with nine or ten large globules of indigo in the belly, which always moved round a centre, and thus showed, in the

most evident manner, that they could not have a communicating canal between the stomachs, provided with an oral orifice and an extremity directed to the mouth.

"But it will be asked, what are these vesicles and balls of the same diameter existing in the bodies of the Infusoria, and which have been taken for stomachs? This question I have continued to ask myself, till an attentive and long-continued investigation has enlightened me as to their origin.

"The true Infusoria are vesicular beings, whose interior are filled with a mucous substance; the thickness of the membrane forming the vesicle, can easily be ascertained in some of these animals; and in many species I have noticed in this membrane an obvious spiral structure, which establishes a complete analogy between it and cellular vegetables. In the large Infusoria, a cylindrical canal (the œsophagus) obliquely traverses the membrane which forms the animal. The lower extremity of this canal dilates, more or less, when the animal has taken food, even till it attains the dimensions of the balls, which are found in the interior of these same Infusoria.

"The inner surface of this part of the intestinal canal is provided with cilia, which turn round, not only the alimentary substances, but also foreign bodies, till they have acquired a spherical form. During the formation of this ball, the stomach (for it is evident we must distinguish this organ by that name) has a free communication with the œsophagus, and by means of the ciliary apparatus found at the exterior, new alimentary substances are introduced into this canal, and pushed as far as the stomach, but I could not satisfy myself whether the œsophagus was likewise beset with cilia in the part which separates the stomach from the buccal orifice. When the ball has acquired the size of the stomach, it is expelled by its other extremity, and pushed into the cavity of the animal. It then forms a new ball, if any solid substances exist in the surrounding liquid. This second ball is itself pushed into the interior of the cavity of the animal, and drives before it the first ball along with the mucosities between the two; the successive formation of similar balls, by the matter received into the animal, continues in the same manner, without interruption. It is the simultaneous existence of many of these balls that made M. Ehrenberg believe that these animals were

Polygastric. If solid substances do not exist in the surrounding liquid, then the balls are less solid, and they appear in the forms which they present in the Infusoria plunged in colourless liquids. In this case, the balls are composed of a small number of particles, and principally of a considerable mucous mass, which unites them. Sometimes two balls of this kind are so pressed against each other by the contractions of the animal, that they at last unite.

"If you wish to follow the formation of these balls, it is necessary to commence these observations at the moment when the Infusoria are plunged into the coloured liquid. The deglutition of the coloured particles takes place very quickly, often in about half a minute, and the coloured balls issue one after another from the stomach, and are pushed downwards along the internal wall of the cavity of the animal. In the genera *Paramecium, Kerona,* and *Vorticella,* the new ball pushes the preceding before it, along with the mucosities between them, in such a manner that the first rises along the opposite wall, returns to the other extremity of the cavity, and is pushed downwards on the other side. The balls thus accumulate in succession, till they are expelled, one after the other, by the anus. The number of these balls is often so considerable, as to fill the whole cavity of the animals, and so close together, that they form a large mass, which turns slowly upon itself, as among the *Vorticella.*

"This rotation is the result of the force with which the newly-formed ball is pushed from the stomach into the cavity, and moves along the under side of the preceding ball. In other cases, where there are not yet many balls, we likewise remark the circular rotation alluded to, but I cannot, in this instance, say what is the cause of it.

"Thus, in the true Infusoria, the substances which they absorb are introduced into the abdominal cavity in the form of balls, and from these the stomach extracts the nutritive substances. The residue remains in these same balls, the mucosities interposed are re-absorbed, and even in the anterior of the stomach the particles of the ball are disintegrated, although this happens but seldom.

"What is the nature of those vesicular cavities, of such great numbers, and so variable in size, which appear in the interior of the Infusoria? They are not stomachs, they possess nothing in common

with the balls of which we have spoken, although the latter may get into them singly, but this can only be considered as accidental.

"We may trace the formation of these cavities, and perceive their sudden and complete disappearance, with as much ease as the formation of the balls. Nay, more, it is sometimes possible to see how one of these cavities moulds itself over a ball, and speedily afterwards disappears. The microscope shows that these cavities are not lined with a particular membrane, but are mere excavations of the pulpy substance. They likewise often appear very near the inner surface of the membrane which forms the skin of the animal, and some of them increase to such a size that their diameter is equal to the third or the half of that of the entire cavity of the Infusoria. The slight refraction which the rays of light undergo at their circumference, proves that these cavities are not filled with air, but by a liquid; and in the large Infusoria, it is easy to satisfy ourselves that they do not open on the exterior. Similar cavities are formed in the mucus of true cellular plants, particularly in certain aquatic Cryptogamia.

"My botanical labours prevent me from carrying these researches farther, but enough has been said to induce the naturalist to pursue them. They require a great degree of perseverance, for it is not easy to establish these facts in all Infusoria, but they are of high importance, since the order *Polygastrica* has already been admitted into many modern treatises on Zoology."—*Ed. Phil. J. vol.* xxviii.

We may add the resumé given by M. Dujardin, of the views entertained by him, regarding the organization of Infusoria. "The Infusoria (leaving out of the question the *Systolides or Rotatoria*, which are much more elevated in the scale of animals, and the *Bacillaria*, which, along with the *Closteria*, are more nearly related to the vegetable kingdom) have their origin, for the most part, from unknown germs, in artificial and natural infusions, stagnant water, and rivers, or such portions as rest over vegetable remains—no other mode of propagation, except self-division, being well ascertained. The fleshy substance of their bodies is dilatable and contractile, like the muscular flesh of the superior animals, but present no absolute trace of fibres or membrane, appearing, on the contrary, homogenous

and diaphanous, save in the cases where the surface appears reticulated from contraction.

"The fleshy substance of the Infusoria, isolated by tearing, or by the death of the animalcule, appears in the liquid as lenticular discs or globules, which refract light but slightly, and are capable of forming spontaneously, in their substance, spherical cavities, analagous, in appearance, to the vesicles of the interior.

The vesicles formed in the interior of the Infusoria are destitute of a proper membrane, and can contract even to so great an extent as to disappear, or, several may coalesce or unite together. Some are produced at the base of a sort of mouth, and are destined to contain the water swallowed with the aliments; they then pursue a certain course, in the interior, and contract, and leave nothing in the middle of the fleshy substance except those particles not digested, or they can evacuate their contents externally, by a fortuitous opening, which may be reproduced several times, although not as the identical, yet towards the same point, and which may lead to the belief of the presence of an anus.

"The vesicles containing the aliments are independent, and neither communicate with an intestine nor with each other, save in those cases where two vesicles incorporate together.

"The other vesicles, which contain nothing but water, are formed much nearer the surface, and appear to be able to receive and expel their contents through the meshes of the tegument. We may, with Spallanzani, consider them as respiratory organs, or, at least, as intended to multiply the points of contact of the interior substance and the surrounding fluids.

"The external organs of motion are flagelliform filaments, or vibratile cilia, or cirrhi, of more or less size, or fleshy prolongations; which, according, as they are more or less consistent, appear formed of the same living substance, and are contractile themselves, throughout the whole of their extent. None are dermoid or corneaceous, or secreted by a bulb. Except some contractile integuments, the pedicle of Verticellæ, and the bundles of horny spicula, which invest the mouth of certain species; all the living portions of the Infusoria decompose almost immediately in water, after the death of the animal.

"The eggs of the Infusoria, their generative organs, their organs

of sense, their nerves and vessels, cannot be exactly determined, and everything inclines one to believe that these animalcules, although endowed with a degree of organization, in accordance with their mode of life, cannot possess the same systems of organs as do the superior animals."

"The coloured points, for example, commonly red, which have been regarded as eyes, cannot, with the least certainty, receive that appellation." (Ann. des Sciences, 1840.)

The recent opinions of Siebold are opposed to those arrived at by the observations of Ehrenberg.

Siebold does not regard the vesicles or sacs, as digestive organs; and the existence of an intercommunicating intestine between them, is altogether denied. The *Astoma* (mouthless animalcules) are described as nourished only by a general absorption from the surface. In the *Stomatoda*, with evident mouths, Siebold represents the mouth as continued into the interior by a sort of œsophagus, wide, differing in length, and straight, curved, or even spiral, terminating abruptly in the general loose parenchyma of the body. When food is sought, it is drawn towards the mouth by the action of the surrounding cilia, and having been received into the mouth, enters the œsophagus, and is thence pushed onward by a contraction of the part, in the form of a rounded globule, and enters the loose interior parenchyma. The food, so introduced, appears mostly like a minute drop of water, it may be holding some solid particles in suspension, after a longer or shorter sojourn in the interior, and a greater or less circuit, it is in most *Stomatoda* ejected through a distinct and fixed anal outlet, and not as Dujardin states, from any portion of the surface indifferently. The anus is generally situated at the opposite extremity of the body to the mouth, and on the under surface, when this orifice is wanting, the nutriment matter is both received and expelled by the mouth, as in Polype. (See Microscopic Cabinet, Plate VII.)

The possession of distinct walls by the vesicles is also not admitted by Siebold, since coalescence is sometimes seen to occur between them. That there is no connecting intestinal tube, is, to the same observer, proved by the great mobility of these globules in the parenchyma, as well as by the fact, that the nutritious particles, first and last swallowed, become mingled confusedly together; and lastly,

by the observation of an occasional circulation within the animal of the vesicles (similar to that of the contents of the cells of Chara, &c.), *in Vaginicola, Vorticella,* and in *Loxodes bursaria.*

This account of the digestive apparatus, by Siebold, agrees generally, with that given by Professor Boeck, of Sweden, (Oken. Isis for 1848). Again Focke states (Reports Ray Society, 1845) "that in *Loxodes, Bursaria, Paramecium aurelia,* and in *Polygastrica,* he saw the cavities filled with pigment, intersecting each other in varied series, and concluded from this, that the digestive apparatus is not separated from the parenchyma, but that the parenchyma of these animals, consisting of cells, encloses the fluid nourishment, received from without in narrow spaces, which may be compared with the intercellular passages of plants. The same observer also states, that on colouring the fluid containing various proboscidated monads, some individuals remained quite colourless, whilst others were saturated with the pigment."

In none of the families included by Ehrenberg under the general denomination of Infusoria, is less indication of a polygastric structure to be met with than in the *Closterina* and *Bacillaria*—the *Desmidieæ* and *Diatomaceæ,* of other authors. It is true that that renowned micrographer speaks in various places of the detection of stomach sacs in several genera of the *Bacillaria,* but the appearances so interpreted, resemble those met with in the vegetable cells of acknowledged Algæ and of other plants, and to which no one has ever thought of assigning a digestive function. These globules, or so-called sacs, are stated to perform an intercellular rotation in the *Desmidieæ,* resembling that of the contents of the cells of Chara, Valisneria, &c. (See Section on *Bacillaria*).

But if Ehrenberg has encountered many opponents to his polygastric hypothesis, he has had a few come to his support, and among the rest, M. Eckhard, once a pupil. The latter speaking of the digestive function, observes, "in such forms as are not too minute, we can distinctly see how the nutriment, artificially supplied, constantly takes a *definite* course in the body; in some instances, the first portion of the alimentary tube can, when not in action, be observed, as in *Epistylis grandis;* it is then frequently seen to be covered on the inner surface with cilia, which, in the *Opercularia,*

may even be counted. But that this alimentary canal does not, after a short course, terminate abruptly in the body, can also be proved in the *Epistylis grandis*."

"In this animalcule, a portion of colouring matter swallowed, is seen to course along an intestine, and enter a cell. I also once attentively observed, what appeared to be the extremity of the intestinal canal, to ascertain what the further course of the coloured particles would be. At this time the animal had not filled any of the cells in its inside; suddenly two lateral cells became filled, although I did not perceive any nutriment pass along the common tube. This clearly points out that the two cells must be in connexion with the common cavity, from which they had become filled, and when, after the animal has fed for a considerable time, we see that similar filled cells are diffused throughout the body, this phenomena affords a ground for the supposition that the intestinal cavity is of greater length than we should at first sight imagine." (Wiegmann's Archives, 1846, translated in Annals v. xviii, p. 433).

Since the above was written, we have met with the opinions of Professors Wagner and Van der Hoeven, as expressed in their recent works: (Wagner's "Zootomie," 1848, Sect. Infusoria; and Van der Hoeven's "Lehbuch der Zoologie," 1850). Wagner affirms that, "by an examination, however close, no one can convince himself of the actual existence of such an organization as Ehrenberg affirms." Like Siebold, he describes the derivation or formation of the vacuolæ (stomach-sacs, *Eh.*) from without, but differs from that observer in not regarding their production as a consequence of the primary introduction of water.

With Van der Hoeven, all coincide in denying the existence of an enclosing wall to the vesicles, and of an intercommunicating tube between them; and all assert the ever-varying number and disposition, as well as the movements (even rotatory) of these supposed stomachs. In the course of argument, Wagner says, that "in many Infusoria, where larger bodies, such as Naviculæ or joints of Algæ, have been swallowed, no surrounding vesicle or sac is visible;" and these large bodies will sometimes occupy the entire length or breadth of an animalcule. Where no mouth is visible, nutrition is carried on by the general surface.

From the preceding conflicting opinions and observations, no satisfactory deduction can be made; Ehrenberg's opinions, however, are entitled to great respect, although the theory of a polygastric structure may not admit of demonstration.

The announcement of Ehrenberg of the discovery of a dental apparatus, must find place in this section. This apparatus occurs in the form of a cylinder of long bristly teeth, placed behind the oval aperture, and is readily seen in *Chilodon*, *Nassula*, *Chlamidodon*, and *Prorodon teres*. See fig. 283.

SECTION XIV.—*Of the Vascular and Respiratory Systems, and of the Secretions of Polygastrica.*—In no creature of this class can a vascular system be satisfactorily demonstrated:—that thought to have been such in *Paramecium aurelia*, was merely clusters of ova.

The above statement follows from the researches of Ehrenberg; but Siebold, Wiegmann, and others, would trace the first outline of a circulatory apparatus in the existence of the contractile vesicle, found in all those with evident mouths *(Stomatoda)*, as well as in a few without such orifice *(Astoma)*, as mentioned in the section on the reproduction of *Polygastrica*. Ehrenberg assigned a very different purpose to the contractile vesicles, regarding them as spermatic sacs, the nucleus being the secreting testis.

The Berlin naturalist mainly based this hypothesis on the similarity of the contractile vesicles to those in Rotatoria, which he fully believed to form a part of the male generative apparatus. But since modern researches have overturned the supposition of the monoecious nature of *Rotiferæ*, and the exposition, consequently, of their generative apparatus, as given by Ehrenberg, all analogies resting on the latter, fall to the ground. Indeed, the argument from analogy would now be the other way; for as such vesicles in the *Rotatoria* have no generative character, it might be assumed that their analogies in the *Polygastrica*, are alike devoid of it.

The contractile vesicles in question, appear like clear hollow spaces in the parenchyma of the Infusoria, the contraction *(systole)* of which, according to Ehrenberg and his pupil Eckhard, (Wiegmann's Archives, 1846, and Annals Nat. Hist. vol. xviii. p. 433), may be regular or irregular, but is defined by Siebold as rhythmical.

In most genera, but one vesicle exists, in others two, and in a few

examples, even more; but, in the latter case, the animalcule is usually in the act of self-division. When more than one vesicle is present, there seems no necessary correspondence between the systole and diastole of each.

With respect to the number of these sacs, in particular species, there is much difference of opinion (only to be reconciled by the observations of others, and by accurate definitions) between Ehrenberg with his disciple Eckhard, and Siebold. The last-named writer affirms that the determination of these vesicles, by Ehrenberg, is altogether arbitrary, one or two being called sperm sacs, and others, just like them, stomachs, as, for instance, in *Amphileptus Meleagris*, and in a *A. Longicollis*. Ehrenberg's views are, however, supported by Eckhard, who finds some difference in the character of the contractions in the different sacs, and affirms that he is unable to verify the existence of the lateral abdominal contractile vesicles in *Stentor* in the elongated one in *Spirostomum ambiguum*, described by Siebold. Vergleichenden Anatomie der Wirbellosen Thiere Vol. I. In Paramecium, the contractile vesicle is large, and has from 6 to 8 radiating prolongations, which are filled when the central reservoir empties itself, and become invisible, when its diastole occurs.

From this, and other like phenomena, presented by these contractile vesicles, Siebold, and others, attribute a cardiac nature to them, supposing that upon their diastole, they become filled with nutritious fluid, derived from the parenchyma, through the insterstices of which it is again forced, on the occurrence of the systole, and stagnation, thus avoided.

The hypothesis of their generative function, Siebold declares perfectly gratuitous; that an incessant projection of seminal fluid from these vesicles, involves, in itself, a supposition opposed to all analogy; and further, that the purpose of the nucleus as a testes, and even the existence of recipient ova in the parenchyma, are more than doubtful.

A process of respiration,—a renovation of the fluid in the parenchyma, and around the animalcule, is no doubt carried on by the external surface, especially by means of the cilia; and, very probably, also by the series of contractile spaces, often seen immediately subjacent to the integument, as well as by the constantly recurring contraction of the supposed cardiac vesicles. The spaces met with

just beneath the surface, are supposed (by Siebold,) to communicate with the surrounding liquid.

That a process similar to that of respiraton is required, is evidenced by the necessity of a supply of air to the existence of Infusoria, small though that supply need be. The more lively animalcules require a more complete aeration of the fluid they inhabit, than do the plant-like *Bacillaria*.

That the faculty of secretion exists, and in an active form, is proved by the production of the more or less hardened Lorica; keeping even the *Bacillaria* out of sight, the hardened cases, as of *Vaginicola*, *Cothurnia*, *Arcella*, &c., or the glutinous investment of *Ophrydina*, &c., bespeak its activity.

SECTION XV.—*Of organs of Sensation in the Polygastrica.*—The existence of any special organs of sensation in this class is but hypothetical, but no doubt can be entertained that the *Polygastrica* have a general sense of contact or of touch. Ehrenberg, however, assumes that the coloured specs, seen in many, have a visual function, and he consequently gives them the name of eyes, or eye-specks. Thus he says, "In forty-eight species, included under the families *Monadina*, *Cryptomonadina*, *Volvocina*, *Astasiæa*, *Dinobryina*, *Peridinaea*, *and Kolpodea*, eyes are observable, and the colour of the pigment is red in all cases, except one, *(Ophryoglena)* in which it is almost black. In connection with the visual organs of *Amblyophis* and *Euglena*, nervous ganglia have been seen, which constitute the only traces of the evidence of a nervous system."

The subjects of this section are thus referred to by M. Dujardin. "The sense of sight would partake more of the character of reality, if the colour of a speck without appreciable organization, without a constant form or a precise contour, sufficed to prove the existence of an eye. But, for instance, in the *Euglena*, which are particularly cited as characterized by such an organ, the red spot so regarded is excessively variable, sometimes multiple, at other times made up of irregularly aggregated granules."

"Analogy, too, is inadequate to the solution of the question; for, on descending the animal series, to determine the nature of the coloured speck, we have to leap from the Daphniœ (members of the *Entomostraca*,) with a moveable eye, repeating in its composition

that of Insects and Crustaceans, to animals presenting nothing but diffused coloured specks.

"Such spots, whether in number or position, have so little physiological importance in the Planariæ, and in certain Annelides, that they are often not even to be employed as an absolute specific character. In the Rotatoria, the analogy with which is more especially insisted on, these pigment spots are, in some species, known to disappear from age, and in others to become more evident, in proportion to size or development of individuals: so that the learned micrographer of Berlin, in his attempt to base the generic characters of these animals on the presence and number of the eyes, has been led to place in different genera, species very closely allied, if not identical. Indeed, that a black or red colour is in general an attribute of the pigment of eyes, cannot be a reason for concluding an eye to exist wherever there is a red colour; if so, indeed, we must accord them to some intestinal worms, such as the *Scolex polymorphus*, which has two red spots on the neck; to the actiniæ, which are often strewed with such specks, and also to some bivalved mollusks."

"If the ability of the Infusoria to direct their course through the liquid, and to pursue their prey, be appealed to in evidence, it is certainly, in the first place, necessary to verify the reality of this faculty, which I think equally fabulous with all related concerning the instincts of these animals. Indeed, it would not even prove the red specks to be eyes, since the greatest number of Infusoria supposed to be endowed with such a faculty, are in want of them; and those which do possess them, do not exhibit that power in a higher degree of development."

M. Ehrenberg, following up his line of reasoning, after having assumed the signification of the red points, has recourse to this assumption, to demonstrate the true nature of certain white specks, more or less distinct, which he supposes to represent nervous ganglions,—"These specks are the only parts of a nervous system spoken of as seen, the rest is altogether furnished by analogy."

Siebold, Wagner, and others, concur with M. Dujardin in denying the visual character of the coloured spots of Infusoria, as well as the presence of nerve matter in an isolated form.

Siebold remarks, that Ehrenberg insists much on the red colour as a distinctive indication of a visual organ, but erroneously so, since other colours prevail in the unquestionable eyes of Insects and Crustacea, such as blue, and sometimes violet or green.

Moreover, the admission that Infusoria possessing eye-specks have a general sensation of light, does not prove the optical nature of those specks, because forms, destitute of them, exhibit a like sensibility of the presence of light, and further, as Siebold observes, if sight be limited to the simple discrimination of light from darkness, this faculty might be secured, without any optical apparatus, by the entire sensitive surface of the body.

According to Morren, the red pigment spots of *Lagenella, Cryptoglena*, and *Trachelomonas*, cannot be eyes, as in the last, the colouring matter may be distributed over the whole body, when the animal, on this supposition, would be changed, *in toto*, into an eye.

The very recent and extended researches of M. Thuret (Sur les Zoospores, in "Annales des Sciences Naturelles," vol. xiv. 3^me^ series, 1850,) on the reproductive gems, or Zoospores of Algæ, prove these bodies to possess red eye-like specks, resembling to those seen in the *Polygastrica*, but which disappear when the Zoospores attach themselves, and germination proceeds. These bodies, moreover, direct themselves, in general, towards the light, and thus exhibit the same form of sensation of its presence, as do the *Polygastrica* themselves.

The general sense of contact possessed by the bodies of the *Polygastrica*, would oftentimes seem to exist in a higher degree in their cilia, proboscides, and other processes, just as in the tentacula or feelers of insects; and so far such processes are special organs of sensation. But even the cilia, and the proboscides of the flagelliform variety, are not peculiar to the animal *Polygastrica*, for they are also found as processes of Zoospores in many Algæ.

Section XVI.—*Reproduction of Polygastrica.*—*Monas vivipara* is, according to Ehrenberg, the only species of this class that is viviparous, though some moving granules observed amongst the *Bacillaria*, have been supposed by him to extend this condition. With this exception, they may be termed oviparous, though besides the formation of eggs, which is a very fertile mode of increase, they also propogate, by means of a self-division of the body of the

animalcule, into two or more individuals; also, by the growth of gemmules, or buds, upon the parent. These various modes of propagation account for their almost incomprehensible increase of number in a very short space of time, and which has often astonished observers.

In the genus *Closterium*, the curious formation of double gems has been observed by Ehrenberg, and is figured in plate I. *fig.* 67. That observer remarks, "The increase by spontaneous division, is the character which separates animals from plants. It is true that the gemmation in plants, especially, in very simple cells, is at times very similar to the division in animals; but this relates to the form, not the formation. A vegetable cell, apparently capable of self-division, produces one, or contemporaneously many exterior buds *(gemmæ)*, without any change in its interior. An animal which is capable of division, first doubles the inner organs, and subsequently decreases exteriorly in size. Self-division proceeds from the interior towards the exterior, from the centre to the periphery; gemmation, which also occurs in animals, proceeds from the exterior towards the interior, and forms first a wart, which then gradually becomes organized."—(*Annals Nat. Hist.* v. ii.)

The importance of this power, so forcibly exhibited in the various tribes of animalcules, is well shewn by the fact, that a creature, invisible to the naked eye, can, in the space of four days, give origin to no less than 140 billions of beings; and as, from the size, &c., of the bodies, we can easily calculate that 40,000 millions of individuals exist in a cubic inch of the polishing slate of Bilin, so 70 billions must be necessary to form a cubic foot of the same structure.

This difference in nature between self-division in vegetable cells, and in the cell-like bodies of *Polygastrica*, above insisted upon by Ehrenberg, is opposed to the result of some recent researches. Thus Mohl and Henfrey state, that when a plant cell is about to undergo fission, the inner mucilaginous layer of its wall—*the primordial utricle* manifests a constriction in the future line of separation, which presently evidences itself in the outer cell-wall, and progresses until the division is complete. (See observations on self-division in the *Bacillaria*, under the sections *Desmidiacea* and *Diatomacea* in part III.

In the *Vorticellina*, M. Dujardin recognizes the existence of repro-

duction by gemmation; but regards the viviparity of *Monas vivipara* as extremely doubtful, and the formation of ova in any Infusoria and their disposition, as far from established. He would, moreover, look upon the appearances observed and considered by Ehrenberg as indicative of oviposition, merely as instances of the phenomenon of *diffluence*, or of the breaking up of the gelatinous substance (*sarcode*) of the animal into spherical atoms, from want of moisture.

Siebold agrees with Dujardin, in thus limiting the process of reproduction to the two forms of gemmation and of spontaneous fission, and from this hypothesis of the non-production of ova by Infusoria, argues the absence of true generative organs. The appearances interpreted by Ehrenberg as evidences of the presence of ovaries, testes, and vesiculœ seminales, afford, according to Siebold, no ground for the assumption of such functions.

The body, presumed by Ehrenberg to be the testis of *Polygastrica*, is generally found occupying nearly the centre of the animalcule, and is readily distinguished from the surrounding loose parenchyma, by its more solid granular character, its clear outline, and generally by its dull yellowish colour.

Although the office of this body in secreting a spermatic fluid may be justly called in question, direct observation being contrary to it, yet this so-called testis, or, perhaps, more correctly, this nucleus, certainly plays a most important part in the well-observed mode of propagation by spontaneous fission; for whenever fission, whether longitudinal or transverse, is about to occur in an animalcule, the first change observed is a progressive constriction of the nucleus, succeeded by that of the body generally. This constriction goes on till division is complete, each segment of the body being consequently provided with a nucleus. The division of the nucleus, as an essential element in the process of spontaneous fission, may be well observed in the transverse division of *Paramecium, Bursaria, or Chilodon.*

Sometimes, two, or even more nuclei, are met with in animalcules, as in *Amphileptus anser and A. fasciola* (figure 314), *in Stylonychia Mytilus, in Stentor coeruleus*, &c.

The nucleus, from the circumstance of being the last part to suffer death, remaining unchanged when the destruction of the surrounding parenchyma is rapidly advancing, may be supposed to partake of a higher degree of vitality.

Professor Owen, in his recent learned and able *Essay on Parthenogenesis*, refers to the initiative, assumed by the nucleus of Infusoria, in their reproduction by spontaneous fission, between which and the essential contact of the spermatozoon with the germ cell, as a preliminary to the primary process of self-division of the latter, in the course of the development of more perfect animals, he indicates an analogy; and, after having completed the comparison of the results in the two cases, goes on to say, "this is certain, that the analogy between these phenomena in the multiplication of the parts of the germ-mass, and those of the nucleus in the multiplication of monads, is so close, that one cannot reasonably suppose that the nature and properties of the nucleus of the impregnated germ-cell, and that of the monad can be different.

"Therefore, I infer, that the nucleus of the Polygastric animalcules is the seat of the spermatic force; it can only be called testes, figuratively, it is the essence of the testis. It is the force which governs the act of propagation by spontaneous fission: and, if Ehrenberg be correct, in viewing the interstitial corpuscles as germ-cells (to which opinion Professor Owen inclines), these essential parts of ova may receive the essential matter of the sperm from the nucleus, which is discharged along with them in the breaking up of the monad, which Ehrenberg regards as equivalent to an act of oviposition; and impregnated germ-cells may thus be prepared to diffuse through space, and carry the species of Polygastric animalcules to a distance from the scene of life of the parent." (p. 67, Ed. 1849.)

Professor Weisse, of St. Petersburgh, has detailed some observations (In the "Transactions of the Petersburgh Academy," and in Wiegmann's "Archives für Naturgeschichte" for 1846,) on the *Chlorogonium euchlorum*, which he considers decisive of the occurrence of reproduction by ova, and, also, as demonstrative of some genera of Ehrenberg, being but different stages of development of the same being. Thus, he describes the contained green matter of the *Chlorogonium* to develope, by spontaneous fission of itself, numerous young animalcules, at their first escape, resembling *Uvella Bodo*, and in further stages, *Chlorogonium euchlorum* and *Glenomorum tingens*. The young beings escape by a transverse rupture of the parent, which, by this form of oviposition, is itself sacrificed, disappearing as a shrivelled broken sac.

But the doubt may arise, whether the being Weisse observed was the true animal *Chlorogonium*, or only a thecaspore or zoospore of an Algæ (see Thuret's Essay, before quoted), a production so similar to the green-coloured Infusoria, that we have really no means of distinguishing between the two, and, what is more, a production which is known to develope by the fission of its endochrome or green contents.

Not only did Ehrenberg discover a testis in the nucleus of *Polygastrica*, but conjectured the pulsating sacs and their prolongations, existing in all those with a mouth, and in some others, to represent a spermatic sac with vas-deferens and vesiculœ seminales. But the majority of observers would rather consider them as the first rudiments of a circulatory system; and we shall defer any further mention of them till that system is considered in a following section.

Before dismissing the subject of the propagation of Infusoria, it is right to notice some recent researches of M. Pineau (Annales des Sciences Naturelles, vol. III. 3rd series, 1845, and vol. IX., 1848), in which he endeavours to prove the transformation of organic matter into definite organic beings, and that there is a perfect analogy between the production of cells in general, and that of animalcules, and of microscopic infusory plants. Moreover, he would extend the phenomenon of transformation to the organised beings when developed.

Thus he states, that in an infusion of different plants, the first index of the progress of organization was a granular mass, subdividing into granular globules. Of these, some of the more advanced presented diverging, but motionless processes; in others more isolated, those appendages exhibited an oscillatory movement, and in them he identified a species of *Actinophrys*. At first, the radiating expansions were all alike, but in the progress of development, one was observed to affix itself to a neighbouring body, and to outgrow the rest. In this form he recognized the *Actinophrys pedicellata* (Dujardin).

He next describes the appearance of a pyriform animalcule seated on a non-contractile stalk, with the trace of a circular orifice, which he believed might be assigned to the genus *Acineta*, whilst the succeeding phase of evolution exhibited perfect *Vorticella*.

M. Pineau, in a second communication in 1848, gave the further course of development, affirming that, at a certain period of their existence, the *Vorticella* undergo metamorphoses analagous to those of insects; that after having passed through a chrysalis-like state, they give birth to an animalcule completely different from their primitive form. (See family *Vorticellina*, Part III.)

Without detailing all the changes recorded by Pineau, it may suffice to state, he saw the *Vorticellæ* lose their pedicles, assume the form of an egg-shaped globule, and eventually, he believes, become converted into *Oxytrichæ*.

Doubting much, M. Pineau's hypothesis of the transformation of formless organic particles into definite organic beings, we would, however, receive his statements concerning the metamorphoses of animalcules with more readiness, inasmuch as many observers have been led to believe in the reality of such transactions; and we may call to mind that, according to Professor Bäer, and his followers, Leuckhart and Reichenbach, the Infusoria, as a class, have no existence, but are merely embryonic forms of higher animals.

That skilful English observer, Mr. Brightwell, of Norwich, also believes that he has detected a cycle of changes in the *Zoothamnium arbuscula*, illustrative of Steenstrup's hypothesis of "alternation of generations;" or of that of a 'spermatic force,' according to the more philosophic interpretation of such phenomena by Professor Owen. (See *Zoothamnium*, Part III.)

Most of the preceding account, of the reproduction of Infusoria, applies especially to those of an undoubtedly animal nature, and but partially to the doubtful organisms of Ehrenberg's families *Closterina* and *Bacillaria*. The latter, besides propagating in common with true animalcules by spontaneous fission, also do so by what is called conjugation, a process peculiar to themselves. However, we shall defer giving an account of this interesting phenomenon, until we especially consider the characters of those families exhibiting it.

We can now state that Wagner, "Zootomie" sect. Infusoria, 1848, and Van der Hoeven, "Handbuch der Zoologie, 1850," agree with Siebold and Dujardin in restricting the reproduction of *Polygastrica* to fission and gemmation, that by ova being denied. All those named, coincide, likewise, in opposing Ehrenberg's views of the contractile

vesicles and nucleus (testis), and would assign to the former, a cardiac or circulatory function.

Spontaneous Generation.—The Infusoria were, very generally, considered to have a *generatio primitiva,* or, in other words, to be produced by some fortuitous combination of circumstances from inorganic matter. That such a statement is untenable, most persons will be inclined to admit, who have perused the descriptions contained in the Third Part of this work. All the observations that can be depended upon, tend to show that infusions of vegetable or animal matters, whether natural or artificial, only offer food for the nourishment of these living atoms, whose germs are almost everywhere present, but are only developed in situations congenial to their natures. It is now well ascertained that the old notions of certain vegetable infusions producing a definite species of Infusoria, is an error; that, in general, we have, in all artificial infusions, only common species, and that these invariably making their appearance, we may fairly presume their eggs are more generally dispersed, and more readily developed. On the other hand, the Rotatoria, and more beautiful species of *Polygastrica,* are confined to localities more open to the fresh air. Ehrenberg, for many years, has experimented with simple spring water, with distilled water, and rain water, and these, both boiled and cold, as also with and without vegetable matter; that in open vessels, after a longer or shorter time, depending upon temperature and other circumstances, he invariably found the Infusoria; while, in closed vessels, they were rarely to be met with; so that it seems, we may consider *generatio æquivoca,* even in Infusoria, as an unphilosophical hypothesis; and that the same fixed laws of Creative Wisdom, which regulate and govern the smallest satellite and the largest starry world through boundless space, has established the same law for the development of a living atom, as is manifested to us in the largest animal that inhabits this planet.

On this subject we may refer the reader to the often quoted experiment of M. Schultz, who contrived an apparatus to prevent the introduction of any living germs, by the atmosphere, in a portion of water experimented on. This experiment has generally been viewed as decisive against the doctrine of spontaneous generation. It is thus recorded:—"I filled, (says Schultz) a glass flask, half full of

distilled water, in which I mixed various animal and vegetable substances: I then closed it with a good cork, through which I passed two glass tubes, bent at right angles; the whole being air tight. It was next placed in a sand bath, and heated until the water boiled violently, and thus all parts had reached a temperature of 212°. While the watery vapour was escaping by the glass tubes, I fastened at each end an apparatus, which chemists employ for collecting carbonic acid; that to the left was filled with concentrated sulphuric acid, and the other with a solution of potash. By means of the boiling heat, everything living, and all germs in the flask, or in the tubes, were destroyed, and all access was cut off by the sulphuric acid on the one side, and by the potash on the other. I placed this apparatus before my window, where it was exposed to the action of light, and also, as I performed my experiments during the summer, to that of heat. At the same time I placed near it an open vessel with the same substances that had been introduced into the flask, and also after having subjected them to a boiling temperature. In order now to renew constantly the air within the flask, I sucked with my mouth, several times a day, the open end of the apparatus, filled with solution of potash; by which process the air entered my mouth from the flask through the caustic liquid, and the atmospheric air from without, entered the flask through the sulphuric acid. The air was of course not at all altered in its composition by passing through the sulphuric acid, but if sufficient time was allowed for the passage, all the portions of living matter, or of matter capable of becoming animated, were taken up by the sulphuric acid and destroyed. From the 28th of May, till the beginning of August, I continued, uninterruptedly, the renewal of the air in the flask, without being able, by the aid of the microscope, to perceive any living animal or vegetable substance, although, during the whole of the time, I made my observations on the edge of the liquid; and when, at last, I separated the different parts of the apparatus, I could not find in the whole liquid, the slightest trace of Infusoria, of conferva, or of mould. But all the three presented themselves in great abundance, a few days after I had left the flask standing open. The vessel which I placed near the apparatus, contained, the following day, *Vibriones* and *Monads*, to which were soon added larger

Polygastric Infusoria, and afterwards *Rotatoria*." (Ed. Phil. Jour. v. 23.)

Section XVII.—*Of the affinities and classification of Polygastric Animalcules.*—Our next business is to determine the affinities existing between the *Polygastrica* and other animals and plants.

Commencing with the simplest; life is seen so obscurely manifested, that in many cases, we know not whether to esteem it vegetable or animal, and the organisms of both kingdoms, in their earliest phase, are, to common observation, identical. In such, there is no other individualization of organs than is necessary to form a centre of generative or spermatic force—*i. e.* a nucleus, in which an energy, originating, each half of the dividing nucleus becomes a centre of assimilative force, and complete fission of the entire being is brought about. Examples in *Monodina*, and in the vegetable *Palmelleæ*.

The next stage in advance, shows so much of the special modification of the general mass, as is necessary to the production of cilia, or of one or more filiform processes or proboscides. Many of the monads afford examples of this degree of development, which is yet so rudimentary and ill defined, that there are no certain means of distinguishing what are specific, distinct animal existences, and what but germs of plants, or the early stages of existence of other animals, or of plants. Here again, therefore, affinities are so close, as scarcely, or not at all, to be separated from identities.

This ciliated monadiform existence belongs to the spores of many plants, and to embryonic conditions of most invertebrata, and, for convenience, is spoken of by Professor Owen, (Op. cit.) as the "Leucophryean type." This type is witnessed in the developing ova of the sponges, and of the Annelida; and there are sufficient grounds for supposing its occurrence, in an early stage of existence, of many of the more highly organized Infusoria.

However, there is one caution to be borne in mind, in seeking for the analogy between specific forms and embryonic phases, viz., not to confound general resemblance with specific identity. If it be not discernible, we must assume (from what we know of the course of development of higher animals) that there is something wanting in the image, to render it an exact counterpart of the original.

But we have to deal, not only with single monads, but with such

beings congregated in masses, when a general analogy may be traced between them and the polypes, grouped together, in the structure of the sponges. Associated groups of monads are met with in the family *Volvocina*, where each individual contributes to the growth of the whole mass, as in the sponge.

Since writing the above, we have met with the excellent essay of M. Thuret, (Op. cit.) in which he discusses the affinity of the Zoospores of Algæ with Infusoria *(Polygastrica.)* He writes: "Their organization presents great analogy with that of Infusoria. The disposition of the cilia is the same in *Pheosphoræ* (a division of the Algæ) as in *Cercomonas* and *Amphimonas*, of Dujardin. But it is between the reproductive bodies of Confervæ, and certain Infusoria, coloured green, that the greatest resemblance subsists. I allude to the *Diselmis viridis*, (Duj.,) the *Chlamidomonas pulvisculus*, of Ehrenberg. In the form of the body, in that of the flabelliform cilia, and in the disposition of those cilia, as also in the contents of the body, the resemblance is complete. The movements of *Diselmis* are like those of Zoospores, and, like them, they tend to the light. In one distinct species, or rather, in a particular state of the same species, a very clear red spot is discernible, and a central globule, very like, in appearance, to the amylaceous granules, so frequent in the cells of green Algæ. These Infusoria appear to act on the atmospheric air, like Algæ, and the green parts of other plants, disengaging a gas (oxygen?) under the influence of light. They exhale an evident spermatic odour. Their reproduction occurs by spontaneous division; 2-4 young ones being formed within the common integument. I have observed the same mode of reproduction in the *Euglenæ*, which act on the air, and turn to the light, like *Diselmis*, but have an extremely contractile body, changing its figure every moment, which will not admit their being confounded with Zoospores, and leaves no doubt of their animality. This binary or quaternary division is met with also in the various species of *Tetrasporæ*, which, though ranged with the Algæ, appear to me of very doubtful vegetable nature. In *Tetraspora gelatinosa*, I have recognised green globules, disposed in fours, and each furnished with two cilia of extreme length, which are lost in the gelatinous mucus, of which the frond of this supposed plant is constituted. All these produc-

tions, as well as *Gonium, Pandorina, Volvox, Protococcus nivalis,* &c., present, in my opinion, characters of animality, too decided, and too permanent for it to be possible to refer them to the vegetable kingdom; and I think it would prove more convenient to unite them, with all the other Infusoria, *(Polygastrica)* coloured green, in one and the same group, which might be called *Chlorozoideæ,*" (Sec. IV.) We have before (Sec. XII.) introduced the sweeping statement of M. Agassiz, and his opinion, that all the mouthless Infusoria are nothing but various forms, and phases of development of Algæ. To avoid repetition, we will also now refer to the same section for that naturalist's views of the affinities of the other groups of *Polygastrica.*

M. Braun would refer the *Volvocina,* (see remarks on that family, Part III.) to the vegetable kingdom, believing them to be of the same type with certain Zoospores, which become composite by fissiparous multiplication; whilst Dr. Burnett, of New York, would associate the *Vibrionia* (see that family) with such Algæ as the *Torula.*

Before proceeding with the affinities of the various Infusoria possessing mouths, we may seek those of the peculiar beings included in Ehrenberg's families *Amœbæa* and *Arcellina,* and known to many naturalists as *Pseudopoda* and *Rhizopoda.* Their muco-gelatinous substance is either naked or defended by a lorica. The former bear the nearest resemblance to minute sponges, but differ, in representing but a single individual, and not a complex aggregation, as do the latter. However, these singular simple numerous masses, when enclosed by a lorica, assume an affinity to a set of beings, often of very elaborate external organization, known as *Polythalamia* or *Foraminifera.* This affinity is so close, that writers are not yet agreed as to which class the Infusoria, or the *Foraminifera,* several genera, ought to be referred. Thus, *Trinema, Euglypha, Rotalia, Vorticialis, Cristellaria,* &c., genera of *Rhizopodes,* according to M. Dujardin, are included by M. D'Orbigny, among his *Foraminifera.* This diversity of opinion must last until the essential characteristics, and peculiar structure of *Foraminifera* are better known. Ehrenberg designates them *Polythalamia,* and would employ, as a distinction between them and his families, *Arcellina, Difflugia,* &c., the fact of the calcareous composition of their shells, stating those of the latter

to be siliceous, not calcareous,—but this difference, it would seem, is questionable.

Mr. Carter, of Bombay, in an able paper on the freshwater sponges, (Transactions of the Medical and Physical Society of Bombay, 1847, Appendix.) points out the close resemblance between the separated individuals, or *Proteans*, to the members of the genus *Amœba* of Ehrenberg, and concludes with the remark:—"Thus does every step towards the ultimate structure of the freshwater sponge, every form that is taken by the living matter of which it is composed, appear still more nearly to approximate it to the nature of the genera of Ehrenberg's *Pseudopoda*."

The next group in advance is characterized by its members having mouths, and which are known to Siebold as *Stomatoda*. The affinities of these animals vary in the case of different families. For although the *Polygastrica*, by their general peculiarities, are separable from all other classes of animals, yet their several families have—setting aside their disputed polygastric structure, hardly any features in common, save their smallness, their habitat, and their simple organization, with, what is important, their propagation by spontaneous fission, and, in almost every case, their want of symmetry. Their general conformation, as seen by the plates, is most varied, as also is their manifestation of life. Some, as the *Vorticellina*, are fixed by a stem to a foreign object, and in many points resemble Polypes, with which indeed they have been classed; and their resemblance is the greater, where the stem is branched and rigid, to Sertularian Polypes.

In its mode of progression, the *Coleps* recalls that of the *Daphniæ*, but all similarity of organization is wanting. The *Euplotes monostylus* presents several characters belonging to the *Rotatoria*, but is asymmetrical, has no such alimentary canal as the latter, and propagates by fission.

Some anomalous forms, such as *Dictyocha*, although, by reason of their siliceous composition, and peculiar conformation, reckoned among the *Polygastrica* by Ehrenberg, would appear to approximate nearer to the *Phytolitharia* than to any other class. The siliceous shelled *Polygastrica* have an affinity also with a class of animals newly discovered and brought together by the indefatigable Prof. Ehrenberg,

which he has named *Polycystineæ.* Several genera of an anomalous form, which he at first classed with *Bacillaria,* he has since united with others subsequently discovered under the above-named appellation. As, however, the internal organization of the *Polycystineæ* is unknown, Ehrenberg contents himself by pointing out their agreement with *Polygastrica* in their siliceous coating (having chiefly in view the doubtful *Bacillaria*) and microscopic magnitude, whilst he indicates, as a distinctive character, the existence of transverse articulations in the *Polycystineæ.*

It would be but an exercise of the imagination to seek after resemblances between the majority of the Infusoria and higher animals, the resemblance could be but fanciful, existing only in external form. In studying the Infusoria, the mind should be unbiassed by a knowledge of the organization of higher animals; we ought not to set out with the assumption that such living atoms must be furnished with the organs of superior existences, and then indulge the imagination, by accommodating appearances, observed to our preconceived notions; but we should rather endeavour to learn under what simple conditions and contrivances, animal life can be manifested and continued.

The so-called class of *Polygastrica* must still be looked upon as an heterogeneous collection of organic beings, which requires the careful and persevering industry of observers to exclude all forms not truly animal, as well as those not having a specific identity, *i. e.,* which are but transitional embryonic forms. Numerous have been the bodies removed from the lists of Infusoria of the older microscopists, by the advance of microscopic knowledge, and by the improvement of the microscope; and we may yet look for equally great modifications of the existing systems, from the genius and ardour of modern research, especially on the subject of embryology.

Since few doubt the expediency of separating the *Closterina,* and many advocate that of removing the *Bacillaria* from the animal Infusoria, we shall defer considering the affinities of those families (which lean rather to the vegetable than to the animal kingdom) to the section especially devoted to them.

As some remarks occurred, in the first edition of this work, relative to the nature of spermatozoa, it may be right to state that the

recent extended and careful inquiries of Wagner, Leuckhart, and Kölliker, (Cyclopædia Anatomy Art. "Semen"), have satisfactorily proved to those writers the non-animalcular character of those organic particles. They have explained their peculiar development, and the essential part they play in the propagation of animals, as low in the scale as the *Rotatoria.*

The discovery of the peculiar spiral and moveable fibres in the antheridia of mosses, by Unger, and called spermatozoa, having kindled much interest, induced me to introduce a description and drawing of them in the first edition (which is retained in the present) under the genus Spirillum. The experiments and observations of Fritsche and others, have exploded the idea (in the opinion of naturalists generally) of those bodies being spermatozoa, or of their possessing an animal nature.

In accordance with Ehrenberg's views of the digestive system, he divides the *Polygastrica* into P. *anentera* and P. *enterodela;* the former destitute of an intestine connecting the several stomach sacs, each of which opens directly into the mouth; the latter possessing one, which, from the various ways it is arranged, gives rise to a further division into *cyclocœla, orthocœla,* and *campylocœla.* In the first of these, the intestine is so curved upon itself, that its two extremities unite at the oral opening—ex. in Vorticellina, and in Ophrydina; in the second, it passes straight through the axis of the body—ex. in Enchelia and Colepina; in the third, it is more or less contorted—ex. in Leucophrys, Trachelina, &c.

But the consideration of the relative position of the oral and anal openings, led Ehrenberg to devise yet another arrangement of the *Polygastrica,* calling those forms *anopisthia,* where, as in *Cyclocœla,* the two apertures are united at the fore extremity; *enantiotreta,* in which, whether in *orthocœla* or *campylocœla,* the apertures are at opposite ends of the animal; *allotreta,* where one is terminal, the other lateral; and, lastly, *catotreta,* where the two orifices are lateral.

As for the *anentera,* he divided them into three sections; the first, comprising those without feet or appendages, *Gymnica;* the second, with variable appendages or processes, *Pseudopoda;* and the third, with cilia, *Epitricha.* (see Tables, Part III.)

Professor Siebold not only rejects the class *Polygastrica*, but uses the term Infusoria in a very limited signification, intending by it only those animalcules moved by cilia. To express the beings known by Ehrenberg as *Polygastrica*, except the *Bacillaria* and *Closterina*, he has devised the word *Protozoa;* and he thus arranges them :—

I. Class.—Infusoria, Animals moving by cilia.

Order I.—*Astoma, Infusoria without a mouth.*

Family 1.—Astasiœa—Genera, *Amblyophis, Euglena, Chlorogonium.*

Family 2.—Peridinœa—Genera, *Peridinium, Glenodinium.*

Family 3.—Opalinœa—Genus *Opalina.*

Order II.—*Stomatoda, Infusoria with a mouth.*

Family 1.—Vorticellina — Genera, *Stentor, Trichodina, Vorticella, Epistylis, Carchesium.*

Family 2.—Ophrydina—Genera, *Vaginicola, Cothurnia.*

Family 3.—Enchelia—Genera, *Actinophrys, Leucophrys, Prorodon.*

Family 4.—Trachelina—Genera, *Glaucoma, Spirostomum, Trachelius, Loxodes, Chilodon, Phialina, Bursaria, Nassula.*

Family 5.—Kolpodea — Genera, *Kolpoda, Paramecium, Amphileptus.*

Family 6.—Oxytrichina—Genera, *Oxytricha, Stylonychia.*

Family 7.—Euplota — Genera, *Euplotes, Himantophorus, Chlamidodon.*

II. Class.—Rhizopoda, Animals moving by variable processes.

Order I.—*Monosomatia.*

Family 1.—Amœbœa—Genus *Amœba.*

Family 2.—Arcellina—Genera, *Arcella, Difflugia, Gromia, Miliola, Euglypha, Trinema.*

Order II. — *Polysomatia* — Genera, *Vorticialis, Geoponus, Nonionina.*

Section XVIII.—*Geographical Distribution of Polygastrica, their relative abundance, &c.*—The *Polygastrica,* as understood by Ehrenberg, are the most widely diffused of all organized beings. From the icy region of Spitzbergen, near the North Pole, to the utmost limit

attained at the South Pole, in the entire circumference of the globe, are these organisms found.

Their distribution in space is co-extensive with that in time; for, as in the present condition of our planet, no portion of its surface seems destitute of Infusorial life, so, it would appear, from the prosecution of microscopic research in connexion with geological facts, that, under this simplest, this primary form, organic life made its first appearance on the globe. Thus, siliceous microscopic beings are discoverable in the oldest rocks above the igneous, and, in many instances, such beings would seem to have played a most important part in the building up of strata. Much of the silica of flint originates from the siliceous cases of extinct *Bacillaria*, and even porphyritic rock, raised by volcanic or igneous agency, is not devoid of examples of such beings.

Thus, through the many epochs of this world's history, during which its surface has undergone the mightiest changes, Infusorial life has been sustained; and so surprisingly so, that forms which now exist, had their specific or their generic types at the very dawn of organization. This implies the extraordinary capability of the Infusoria to preserve life, as also their no less wonderful power of multiplication. Yet, notwithstanding the conservative and reproductive power of microscopic life, and its consequent capacity for almost unlimited diffusion, some definite law is manifest in many cases of geographical distribution.

The untiring industry of Professor Ehrenberg, in examining recent and fossil specimens, sent to him from almost every known region of the globe, has disclosed the fact, that although some species are cosmopolitan, not a few may be taken as characteristic of certain geographical areas. To give an example, we may quote from a recent paper, read by that great microscopist, before the Berlin Academy, on a very extensive layer of siliceous *Polygastrica* in Oregon:—"The chain of rocky mountains traversing the continent of North America, forms, with reference to the distribution of Infusoria, a stronger barrier between California and Oregon, and the rest of the continent, than does the Pacific Ocean, with China, between the Western Plains of North America, and the Region of Siberia. Thus, the United States, with Mexico, never present any of

the forms characteristic of Oregon and California; whilst, on the other hand, the peculiar forms of these latter countries are met with in Siberia. All this is remarkably confirmed in this, that the gold region of the Sacramento, in the extent and abundance of its Infusorial products, finds its parallel only in Siberia." (Monatsbericht, Berlin Acad. Feb. 1849.)

Most of the preceding remarks apply with greater force to those siliceous shelled microscopic organisms included in the great family *Bacillaria*. It is these beings which at previous eras have built up rocks, raising land from the sea bottom, and which now, by their indestructibility, admit the extensive review of their distribution in time and space made by Ehrenberg. Whereas the illoricated, soft, and evidently animal Infusoria, have, by their destructibility, been removed from the sphere of our investigations into their diffusion in past time. Yet sufficient has been made out to indicate the prevalence of a law of distribution in space even in their case.

The determination of species characteristic of certain climes, has enabled Ehrenberg to arrive, in many cases, at the probable source of those meteoric showers of dust which occasionally occur. For instance, those which fall in the Atlantic about the Cape de Verd Islands, and as far eastward as Genoa, Malta, and other districts of Southern Europe, are found to be made up from 1-3rd to 1-6th of organic matters, chiefly of *Polygastrica;* and although most of the species alike occur in the most widely separated places mentioned, and are of fresh water habit, yet there are others of limited and special distribution. Thus the Sirocco dust, which fell in Genoa in May, 1846, contained *Synedra Entomon*, a characteristic South American form, along with African species; the latter, however, being in no greater quantity than in other dusts falling within the limits above spoken of. From this, Ehrenberg surmises that there is a current of air uniting Africa and America, in the region of the trade-winds, and occasionally directed towards Europe.

In the various kinds of meteoric dust, Ehrenberg has determined no less than 320 specific forms of *Polygastrica*, *Phytolitharia*, *Polythalamia*, and the soft parts of plants. The predominating genera of *Polygastrica* (marine and freshwater,) are *Coscinodiscus*, *Diploneis*, *Goniothecium*, *Grammatophora*, and *Biddulphia*. In Ehrenberg's

elaborate paper entitled "Passatstaub und Blutregen," (folio, 1849, Berlin,) is presented a complete history of the showers of meteoric dust, &c., which are on record, and the microscopic analysis of the various specimens which he has procured.

It happens with the *Polygastrica*, as with all other classes of organized beings, that some families and genera are much more widely diffused, and of more common occurrence than others. Everywhere, where there is decomposing organic matter in water, *Vibrionia*, *Monadina*, and *Leucophrys*, will be found. Examples of the genera *Vorticella*, *Volvox*, *Paramecium*, *Kolpoda*, *Oxytricha*, and *Euplotes*, &c., are common in ponds and streams at all parts of the world, and often in great numbers. Equally widely diffused are the two sections of the family *Bacillaria*—*Desmidieæ* and *Diatomaceæ*, the latter is prominently cosmopolitan, and, in the abundance of its members, unsurpassed. (See Part III.) Of the last section, the richest genera are *Eunotia*, *Navicula*, *Surirella*, *Pinnularia*, *Gomphonema*, *Cocconeis*, *Stauroneis*, *Actinocyclus*, *Gallionella*, *Dictyocha*, *Synedra*, *Coscinodiscus*, and *Schizonema*.

We have several times alluded to the abundance of fossil *Diatomacea*, which sometimes constitute the almost sole ingredient of masses of rock or earth; as, in the mountain meal (*Berg-mehl*); in various polishing powders; in the pure siliceous sand employed in the manufacture of porcelain, &c. And, inasmuch as any particular fossil deposit, generally, possesses some peculiar species, or a particular collection of species, it has happened that the antiquarian has been able to determine, that various ancient articles of pottery have been made from the particular layer of clay in their vicinity, or, otherwise, have been brought from a distance.

Section XIX.—*Of the Rotatoria as a class, and of their habits and movements.*—This tribe of beings possesses so complete an organization, that in a correct arrangement of the animal kingdom, it would take its station far above many others, whose members are of much larger magnitude.

The comparatively large size of the *Rotatoria*, and the transparency of their integument, have enabled the microscopic observer to ascertain with certainty, in many cases, every part of their internal

structure. As a tribe, it is evidently more natural than that of the *Polygastrica;* at least there are no such doubtful families as we find in the latter, namely, the *Closterina, Bacillaria,* &c. Indeed, the only exception, that can probably be taken, is the genus *Stiphanoceros,* which some naturalists class along with the Zoophytes.

The *Rotatoria* (sometimes spoken of also as *Rotifera*) are symmetrical beings, and derive their name from the apparent whirling, wheel (*rota*)-like motion of their rotatory apparatus, when set in action; but since, in some instances, the apparatus is so modified that a wheel-like motion is wanting, another appellation has been contrived—viz., *Systolides,* to designate these animals. It is from the very contractile character of their bodies that Dujardin so terms them; and, indeed, some other name than *Rotatoria* is requisite, if this naturalist be followed in introducing in the class various animals, furnished with rudimentary limbs, in pairs, but wanting a rotatory apparatus, and, generally, so modified in structure, as to be fitted for a parasitic existence within the bodies of other animals—such are the members of the family *Tardigrada,* (*Duj.*)

In such an arrangement, Mr. Adam White seems disposed to agree with the French naturalist, for he has stated it as his opinion, "that the so-called *Acarus folliculorum,* and, probably, also *Tardigrada,* are parasitic *Rotatoria,* with legs or leg-like appendages adapted to their peculiar habits; and that their retractile antenna-like, sub-telescopic appendages, may have eyes passing through them as in snails, and may also be the equivalents of the *rotæ* (*rotary lobes*), but from the limited, or rather the absolutely restricted power of motion of these animals, have neither the ciliary processes, nor the movements and economical uses of the appendages so characteristic of most of the *Rotatoria.*" (Read before the Linnæan Society, June 1851. See Ann. Nat. Hist., vol. vii. p. 424.)

The *Rotatoria* are microscopic objects, although many of them are visible to the naked eye as floating specks. They are specially inhabitants of pure water, not occurring in infusions, unless of very recent plants, in which decomposition has not begun. For instance sage-leaves, clover, or chopped hay, are often put to macerate in water, in order to procure specimens of *Rotatoria*; the appearance of

which, under such circumstances, we may consider due to the existence of their eggs, upon, or about such vegetable matters, or to the presence of the animals themselves in a dried state.

The *Rotatoria* especially delight to live in still water, among growing aquatic plants, such as *Conferva, Lemna, Ceratophyllum, Hottonia,* &c., to which they frequently adhere. They inhabit both fresh and salt water, but are more numerous in the former.

Immersion in water is, however, not necessary to their existence; for they are to be found also in damp or moist earth, as in the earthy deposit from the rain-water spouts of houses, in the detritus of walls, roofs, &c., upon mosses and Lichens, such as the tufts of *Bryum,* and about the mosses growing on the roots of trees, such as the *Hypnum.* From such plants as mentioned, they may be separated, by washing with a little water.

It is a curious fact, however, that they sometimes establish their residence within the cells of mosses and Algæ, where they are apt to be made prisoners in the progress of growth of the plants.

Their capability of being completely dessicated, and of being subsequently revived, has been previously spoken of in Section VIII. Ehrenberg has seen, in the *Hydatina,* life prolonged eighteen to twenty days; but its duration will greatly depend on the circumstances of temperature, &c., under which the *Rotatoria* are placed. By far, the majority of *Rotatoria* have the power of locomotion, but several genera form exceptions, their members mostly being fixed by means of a contractile pedicle.

These attached forms are enveloped by an outer tubular case, within which, they can entirely withdraw themselves by means of their pedicles, or, from which, they can extrude the greater part of their body, when in search of food; they thus enjoy a certain latitude of motion, suitable to their peculiar condition.

The locomotive *Rotatoria,* on the other hand, exhibit great activity and variety in their movements. The greater number swim along in a uniform manner, by means of the ciliated rotary organ ex. *Brachionus;* others, in addition, crawl like leeches, by alternately advancing, and using as fixed points, the head and the suctorial extremity of the tail, ex. *Rotifer;* whilst a few skip or leap after

the manner of the Daphnia or water-fleas, by the action of bristle-like appendages, ex. *Triarthra.*

On these varieties of the movements of *Rotatoria* it is, that M. Dujardin bases his primary divisions of the class.

Section XX.—*Of the External Coverings, of the Muscular System, and of the Organs of Locomotion of Rotatoria.*—The external surface of *Rotatoria* is made up of a smooth and firm integument, more delicate at the anterior extremity or head of the animals, where it becomes ciliated. Its contractions coincide with those of the subjacent parenchyma, whence it is not drawn into folds. In many instances the integument presents transverse or circular markings, indicating the division of the body into segments, as in the *Crustacea.*

The usual smooth condition of the integument is departed from in the genus *Choetonotus,* (figs. 357-358) and in *Philodina aculeata,* (figs. 487-489) the surface is strewed with stiff bristles and styles—whilst that of *Noteus* (figs. 491-494) and of some *Anurœa,* is roughened by granular eminences.

The caudal extremity exhibits the transverse wrinkles most strongly, and in many cases is clearly divided into segments, as in *Conochilus,* (figs. 365-370) *Megalotrocha,* (figs. 374-375) *Lacinularia, Noteus,* &c. In various species of *Hydatina, Rotifer, Eosphora, Philodina, &c.,* not only the caudal portion, but the rest of the body, is also divided into segments, which will slide upon one another like the tubes of a telescope.

A rigid horny shield, resembling, in structure, that of Daphniæ, is met with in *Brachionus, Anurœa, Noteus,* &c. Within the outer, firmer tunic, Mr. Gosse describes an inner, softer one, into which the muscular cords are inserted. (See those families.)

Some *Rotatoria* possess, besides the integument immediately investing them, another external to it, and surrounding it in the form of a sheath, to the bottom of which they are fastened. This sheath (*urceolus*) varies in kind as well as in form; thus, in *Lacinularia* (fig. 378) it is gelatinous, and the animal imbedded in it; in *Melicerta,* (figs. 386-387) the animal can move freely within its gelatinous case, which is here strengthened by adherent foreign particles, the same, in a less degree, obtains in *Oecistes* (fig. 362); and in *Limnias,*

(fig. 388); whilst the cases of *Floscularia,* (fig. 384) *Tubicolaria,* (fig. 379) and *Stephanoceros,* (fig. 383) are loose and hyaline.

These outer gelatinous and tubular sheaths, are clearly, products from the animal, which secretes them, as the coral-animals do their cells, or the mollusca their shells. (See *Melicerta* and Plate XXIII.)

In the genus *Chætonotus,* Dujardin even denies the existence of a proper integument, and ranks it with the *Polygastrica.* (For a summary of the external processes of *Rotatoria,* see Section II.)

In this class, a muscular system, subservient to the functions of locomotion, nutrition, &c., is well developed, and the integuments being transparent, its structure and disposition are distinctly visible under the microscope, without dissection. The principle muscular member is a foot-like non-articulated process, situated on the ventral surface of the posterior part of the body. This member is usually called the tail; but being situated anteriorly to the discharging orifice, is not properly such. It has usually the faculty of being able to slide one part within another, and recalls to the observer the movement of the sliding tubes of an opera-glass, or telescope. Its extremity is often so formed, that the creature can cause itself to adhere to any substance, by probably producing an exhausted cavity within the disc-like extremity, as do the leech and some parasitic acari found on beetles. Sometimes the termination of this false foot has two or more toe-like processes. By the construction of this member, the creature is enabled to attach itself, while the anterior part is moving about in search of provender, and likewise to employ it as an instrument of progression, by alternately contracting and elongating it, and fixing itself by it and the mouth, after the manner of a leech. Muscles for moving the body, and the rotatory organs, are mostly visible; they are known by their thickening during contraction, and by dilating when elongated.

With reference to their arrangement, the muscles form two sets—the one, *annular,* encompassing the body; the other, *longitudinal.* The former are separated from each other by considerable intervals, and give to the body the appearance of being divided into several transverse segments. The longitudinal muscles arise from the integument, and proceed forward to be attached to the œsophageal bulb, or to the rotary apparatus, or else backwards to the tail, with its

several sliding segments. Very fine muscular threads are likewise employed to keep the viscera in their places; and some transverse ones crossing the general cavity of the body, have, in some instances, been seen. (Plate XXIII, fig. 5.)

Mr. Gosse says: "All the cuticular insertions (of the muscles) are in a skin separable from the outer integument. . . . The coronet of thickened masses that surround the head is probably muscular, bearing the cilia. Just below this (in *Asplancha priodonta*) there is a series of five or six annular threads, set in the inner skin, which are probably muscular, and aid in the complex movements of the head. The reniform cushion that bears the jaws, is, doubtless, composed of powerful muscles; and the delicate stomach with its tube, the great crop and the ovisac, are covered with a muscular network."

The muscles of the *Rotatoria* have a clear, distinct outline, but are not transversely striated, and belong to the unstriated muscular tissue of anatomists.

Dujardin (Histoire des Infusoires, p. 557) is the only recent writer we have met with, who denies the existence of distinct muscles in this class. He would attribute the movements witnessed, to the operation of a soft, diaphanous, diffluent substance, subjacent to the integument, which he further supposes to possess an inherent property of contractility. This same author excludes the genus *Chætonotus* from the *Rotatoria*, under the impression that it does not present the characteristic contractility of the class, and, above all, that it has no true rotary organ.

The most singular and interesting organ in these creatures, if not the most remarkable structure in the animal kingdom, is the so-called rotary or rotatory organ; it consists essentially of a whorl of cilia, seated on a contractile base, forming the head of the animals. It constitutes the principal means of locomotion, the tail process being, in most cases, less concerned. Even where the animal, by the alternate fixing of its mouth and tail, can progress like a leech, it can, also, more rapidly advance by the propulsion of its ciliated wheel apparatus.

The rotary movement of this apparatus was, at one time, looked upon as a reality, but is now regarded as only apparent. Dutrochet attributed the phenomenon to the undulation of a delicate membrane

fringing the head of the *Rotatoria*. Faraday explains it by supposing the distinct cilia to become visible by slowly returning to an erect state, after having been suddenly bent previously. Ehrenberg again assumed the existence of four muscles at the base of each cilium, each acting upon it in its own direction, and so producing a revolution around the fixed point of attachment or base of the cilium. In this way each cilium would be alternately nearer to, or more remote from the eye, and, consequently, more or less visible.

Another explanation has been offered by Dujardin. He says, "The vibratile cilia being arranged parallel, and at equal distances, will equally refract or intercept the light, and none will be more visible than the rest, but if, by a movement propagated along the row of cilia, some, momentarily inclined, are brought into juxtaposition with adjoining cilia, the light will be more intercepted, and a band, more or less dark, will be the result. It can be imagined, therefore, that if the cilia come to be inclined one after another, a series of juxta-positions, or of apparent intersections, will be produced, and this, in the direction of the general movement. Further, if each of the intersections preserves the same form as if produced by a number of equal lines, and are equally inclined to each other, an appearance of a solid body of a definite form, like the tooth of a saw or the spokes of a wheel, moving uniformly, presents itself to the eye."

The situation, number, and disposition of the rotatory organs, are employed in the grouping of the *Rotatoria* into families and genera.

The rotary apparatus is single, double, or made up of several portions. Its wheel-like motion is most evident where the rotary apparatus forms an unbroken circle, as in *Conochilus*, (figs. 365-370) *Philodina*, (figs. 487-490) and *Actinurus*, (figs. 481-484.) Where the apparatus is interrupted by a notch, and is made up of two or more smaller distinct wheels, the delusion of complete revolutions is removed, as in *Hydatina*, (fig. 394) *Notommata*, (figs. 418-420) *Diglena*, (figs. 403-405), &c. Exceptional forms are exhibited in *Floscularia* and *Stephanoceros*.

The action of the rotary apparatus may be arrested at the will of the animal, or the entire organ be retracted within the body.

In addition to the rotary organ, the head is sometimes crowned by

several styliform processes, moveable, but not ciliated; examples of such organs are to be found in *Salpina*, (figs. 447-453) *Monostyla*, (figs. 434-437) and *Brachionus*, (figs. 499-501.) In *Floscularia* (figs. 384-385) indeed, five to six lobes, with long radiating cilia, constitute the so-called rotary organ of that animal; whilst *Stephanoceros* (fig. 383) offers a still wider departure from the normal form, in having five long ciliated arms proceeding from its head, and no true rotary apparatus existing, thus establishing a great affinity, in external form, with the Bryozoa, or Ciliobrachiate Polypes.

Although the true *Rotatoria* are destitute of locomotive members on their under surface, yet an approach to such organs is indicated in the toes, or pincer-like processes of the tail, before alluded to, as attached to its extremity, and sometimes, in addition, to one or more of its segments. If the *Tardigrada* (see end Part III.) of Dujardin, be admitted among the *Rotatoria*, then the latter will comprehend animals with distinct, rudimentary legs or feet, by means of which they can crawl.

Besides the rotary organ, and the tail with its appendages, other special instruments are met with in the stiff-bristles, (cirrhi) of *Polyarthra* (figs. 401-425) and *Triarthra* (figs. 406-408), in the former, fixed on each side of the neck, and moved after the manner of oars; in the latter, articulated on the under surface of the body, and giving the animal a very active leaping movement, like that of a flea.

The true telescopic tail is wanting in several genera and species, as *Anuræa;* others have a short pincer-like process, as *Chætonotus*, (figs. 357-358) *Eosphora*, (fig. 415) *Cycloglena*, (figs. 425-426), &c.; others, two long styliform processes, as *Notommata longiseta*, (fig. 421) *N. Felis*, &c., whilst others again have a single style of greater or less length, as *Rattulus*, (fig. 409) *Monocerca*, (fig. 399-417) *Monostyla*, (figs. 434-437) and *Mastigocerca*, (fig. 438-440.)

But besides the locomotive *Rotatoria*, there are fixed forms, many of which have a posterior prolongation, rather deserving the term pedicle or stem, than that of tail or foot-like process. This pedicle is contractile throughout, or only in part, corrugating itself, and having no sliding segments; examples are seen in *Tubicolaria*, (figs. 379-382) *Stephanoceros*, (fig. 383) *Limnias*, (fig. 388-392) and *Melicerta*, (fig. 386-387.) The contractility of the foot enables these

fixed *Rotatoria* to withdraw themselves within the investing sheath, or tube, within which they live, after having previously extended themselves beyond it.

Dr. Dobie, in his account of the species of *Floscularia*, describes their "cilia as of two kinds; one of the usual short vibratile kind, covering the interior of the alimentary tube; the other, extremely long and filiform, of uniform thickness and not vibratile under ordinary circumstances. They are slowly moved, and spread out by the contractile substance of the lobes of the rotatory organ." He adds, "when a solution of caustic potash is brought in contact with the filiform cilia, a most violent vibratile action immediately commences, and continues till the whole bundle is completely disorganized. Violent mechanical stimulation seems to have a similar effect, though in a less degree."

The form of cilia, described by Dr. Dobie, on the rotary apparatus of *Floscularia* is exceptional, the general kind, imparting the surprising locomotive power of the organ, being short and actively vibratile. (See Wood Engraving, Part III.)

Dr. Dobie found "immediately below the integument of *Floscularia cornuta*, groups and lines of very small granules, continually in a state of rapid molecular motion, in appearance, exactly resembling the molecules in the cusps of *Closterium*. Besides the molecular, they are subject to another motion, for occasionally they move from one part of the surface to another, in currents not very distinct or persistent, and in no definite direction. He has seen them running in lines down the tail, and collecting in groups. This flowing movement occurs chiefly during the contractions and relaxations of the entire animal. He thinks it probable that these granules are connected with the nutrition of the animal, and analogous to the free floating corpuscles of the *Tardigrada*, described by M. Doyère." (Ann. Nat. Hist. 1848, p. 233.)

SECTION XXI.—*Of the Digestive System of Rotatoria.*—The *Rotatoria* possess a distinct and undoubted alimentary canal, evident as a tube traversing their interior, from the mouth to the posterior outlet, having a certain definite position, and absent in only a few instances,

Food is drawn into the mouth, by means of the vortex, occasioned

by the action of the curious rotary organ, (described in the last section) which surrounds that opening. It, first of all, enters a short cavity, known as '*the crop*,' and is then submitted to the action of horny jaws, mostly armed with teeth, and enclosed in a powerful muscular apparatus, forming what is called the œsophageal head, or bulb Separate drawings of this bulb, with the different arrangement of the teeth, are shewn in figures 377, 382, 383, 396, 420, 424, 433, 437, 444, 455, and 456. It next passes through a canal, the œsophagus, into a dilated space, termed the stomach, and, after due digestion, is propelled thence, through an intestine, to the outlet.

The whole course of the alimentary canal is mostly straight, but, in some *Rotatoria*, for instance, in *Tubicolaria* and *Melicerta*, it presents a slight coil. The canal is lined by vibratile cilia, which assist in the introduction and propulsion of food.

The portion of the alimentary tube, immediately posterior to the mouth, is funnel-shaped, and hence, called by Dr. Dobie, the *infundibulum*, having its edge frequently divided into lobes, (see fig. .) This space is separated by a rim, armed by non-vibratile cilia, from the next portion, called, by M. Dujardin, the *vestibule;* and which leads into a very dilatable cavity, called the *crop*, a fissured partition, or diaphragm, intervening between the two. The *crop* ends below, in, or in some measure, contains the œsophageal bulb, with its usual armature of teeth, supported on horny jaws, and separable by pressure.

This manducatory, or chewing apparatus, has been compared to the gizzard of birds, which it resembles in function, but is, otherwise, more like the crushing toothed apparatus, in the stomach of crabs, lobsters, &c. The number, form, and arrangement of the teeth, afford excellent characters for the systematist; and will be found figured, in the case of many genera, as referred to above.

In most instances, the œsophageal bulb, although enjoying considerable latitude of motion within the body, does not project from it; but, in some single-toothed forms, ex-*Brachionus*, with the rotary organ divided, this bulb protrudes beyond the mouth, and thus becomes a prehensile organ, using its teeth like claws or pincers.

The jaws supporting the teeth, are of a horny consistence, and are mostly furnished with two bent geniculate processes, one anterior, the other posterior, in position. These processes serve for fixing the jaws more firmly in sitû, and, in addition, furnish powerful leverage for the muscles working them. The jaws are further complicated in some many-toothed *Rotatoria*—such as *Philodina*, *Lacinularia*, *Melicerta*, by the development of arches to support the teeth.

The rubbing together of the opposed surfaces of the horny jaws, may be readily observed, and a sort of peristaltic contraction, nearly incessant, is also noticeable in the œsophageal bulb, which surrounds the jaws as a muscular investment. The peristaltic contractions of the bulb, led the older observers to entertain the idea that it was a heart—the contractions representing its pulsations.

The œsophageal bulb and teeth are the first perceptible organs in the embryonic *Rotatoria;* and a backward and forward, or peristaltic motion, may be noticed in the bulb, even before the escape of the young animal from the egg.

In *Chætonotus*, this characteristic manducatory organ of the *Rotatoria* is not distinguishable, and, most likely wanting:—for this reason, as well as others, elsewhere named, Dujardin excludes this genus from the order.

Beneath the œsophageal bulb, the digestive tube undergoes another enlargement, constituting a stomach—the connecting narrower portion interposed between the two, being generally known as the œsophagus. Mr. Goss, unfortunately, however, applies the term œsophagus, to the first portion of the alimentary canal, between the mouth and *crop;* but the preceding application is more usual. (Description of *Asplanchna*,—Ann. Nat. Hist. 1850.)

The œsophagus varies much in length, in different *Rotatoria;* and very great differences are observable in the degree of development of the stomach; for, in some genera, the digestive tube continues as a simple, funnel-like tube, into its termination, in which case, consequently, a stomach cannot be rightly said to exist, whilst, in others, on the contrary, the stomach is a considerable cavity, and not unfrequently sacculated.

The canal narrows again below the stomach, forming an intestine, the rectum varying in length in different species, and ending by a

very dilatable portion, opening externally, and which, from serving, also, as a conduit for the eggs (in the female,) is analogous to the cloaca of birds. It always opens at the base of the footlike tail.

Every portion of the alimentary tube, except the muscular bound œsophageal bulb, is capable of great distension; and this is particularly noticeable in the crop, stomach, and cloaca, in the last, during the process of oviposition, the eggs of *Rotatoria* being of very large size.

A very curious exception to the general rule, of a digestive inlet and outlet in *Rotatoria*, has been observed by Mr. Gosse, in the genus *Asplanchna*, for it has "no anal orifice, nor any intestine below the stomach; the remains of the food, when digested, are regurgitated by the contraction of the viscera, and discharged through the mouth," as in Polypes.

Special organs of secretion exhibit themselves in this class, under their simplest form, as sacs, or cells containing coloured fluid, and opening into the alimentary canal. Attached to the œsophagus, or to the upper part of the stomach, is a pair of glands, usually of an oval form, but sometimes, though rarely, cylindrical or forked, and considered by Ehrenberg, to represent the pancreas. Besides these, coloured sacs, with yellowish brown, or greenish granular contents, are often to be seen external to the stomach and intestine, into which they pour their secretion by gall-ducts—as Ehrenberg thinks is evident in Enteroplea—the secreting cells themselves being the liver, on biliary glands. Siebold states that the pancreatic glands are absent in the *Icthydina;* whilst in some species, as *Notommata clavulata, Diglena lacustris,* (fig. 403,) and *Megalotrocha albo-flavicans,* (figs. 374-376), they are complicated by additional sacs or tubes.

In *Asplanchna,* Mr. Gosse describes "several yellow glandular (?) spots, varying in number," on the top of the cushion of the œsophageal bulb. In *Floscularia campanulata,* Dr. Dobie observed large fixed granules distributed here and there, throughout the body and tail, most nearly resembling globules of oil.

The glandular bodies concerned in the process of reproduction are described in the section devoted to the consideration of that process.

The preceding account of the digestive system of *Rotatoria,* applies, in the main, to the females only; the recent discovery of the male *Rotatoria,* has also shewn an organization, peculiar to them-

selves, but far inferior in type, to that of the females, in every structure, save that devoted to the continuation of the species.

The discoverer (Mr. Brightwell) of the male beings, could distinguish no jaws, gullet, stomach, nor hepatic organs, and, indeed, no appearance of extraneous matter being received into the body. Mr. Gosse, in describing the male *Asplanchna*, says :—"the place of the stomach was occupied by a long sac, having a slender neck, originating from the front part of the head mass, and, at the bottom, broadly attached to the sperm-bag." (Plate XV, fig. 65, 66, and Plate XXIII, fig. 7, 8.)

Section XXII.—*Of the Vascular and Respiratory system of the Rotatoria.*—The vascular system in these animals, according to Siebold, is most probably one circulating only water, and which, by its organization and character, must be also considered to serve a respiratory purpose. There exists, for instance, in most *Rotatoria*, on each side, a small band-like organ, through which an apparent vascular canal winds. At the anterior extremity, these two side bands, with their contained vessels, become connected with other short lateral vessels, which open directly into the abdominal cavity, having their orifices furnished with freely oscillating or vibratile flaps. The number of vibratile orifices varies in different species, and, it would appear, even in different individuals of the same species. Usually, two or three are met with on one side, and from five to eight on the other; but, in not a few, a much greater number exists, as in *Notommata clavulata*, and *N. myrmeleo*, while in the genus *Floscularia*, Dr. Dobie states the tremulous gill-like organs to be absent. (Plate XXIII, fig. 6, 9.)

At the posterior part of the body, the two side bands approach and unite in a common thin-walled trunk or contractile sac, which, by its active contractions, forces out its fluid contents through the cloacal opening.

In the neck of most *Rototaria*, is also placed a projecting tubular process, sometimes two, through which, in all probability, the water enters the interior of the body, and passes into the water-circulating system just described. Admitting the tube to have the office assigned it, it may be justly called the respiratory tube. Mr. Gosse is led to regard tubes or processes of this character rather to be

rudimentary antennæ; and that observer consequently appears to agree with M. Dujardin, in questioning their tubular structure.

The excellent description by Mr. Dalrymple of a new genus of *Rotatoria—Asplanchna Brightwellii, Gosse*—(Phil. Trans. 1849, p. 334), affords us a very clear account of the circulatory apparatus, differing in some points from that which we have borrowed from Siebold. He says, "This peculiar organ consists in a double series of transparent filaments (for there is no proof of their being tubes or vessels), arranged, from above downwards, in curved or semicircular form; symmetrical, when viewed in front. These filaments, above and below, are interlaced, loop-like; while another fine filament passes in a straight line, like the chord of an arc, uniting the two looped extremities. To this delicate filament are attached little tags, or appendices, whose free extremities are directed towards the interior of the animal, and are affected by a tremulous, apparently spiral motion, like the threads of a screw. This is undoubtedly due to cilia arranged round these minute appendices. The tags are from eight to twelve, or even twenty, in number, varying in different specimens. (Plate XXIII, fig. 6*a*.)

"I believe the organ in question to be a peculiar circulatory system. The body of the animal is filled with fluid, most probably analagous to blood, while the ciliated tags, in perpetual motion, must produce currents in this fluid, and probably in an uniform and determinate direction. In this way the nutrient plasma will be brought regularly in contact with all parts of the body, and the process of nutrition go on as in insects, without the intervention of tubular vesssels, the dorsal heart, in them, serving only to give direction and circulation to the blood. I am the more impressed with this belief, since these filamentous organs are in close approximation with the large contractile sac, which probably performs a respiratory function."

For it will be seen, from the following extract, that Mr. Dalrymple does not believe in any communication between the sac and the apparatus furnished with the ciliated tags, as Siebold supposes; on the contrary, the former writer makes the sac to communicate directly with the exterior. He writes, "This sac, spherical when distended, is placed just above the ovisac, and communicates with

the vaginal canal. It is exceedingly delicate, and may be seen to contract, by the action of muscular fibres, with great rapidity, in which act it is thrown into numerous regular folds or pouches, and in that condition appears not very dissimilar to the large cellular lungs of Batrachia.............The explanation which I venture to give, is, that this sac draws in water and expels it again by the vaginal orifice; and it is by bringing the blood, by means of the ciliary movements of the tags, into intermediate contact—(the delicate membranous wall of the sac intervening) with the air of the water, that aëration or respiration is performed. An analogous contractile sac may be seen in *Rotifer vulgaris*."

Ehrenberg described the several organs discussed, assuming the existence of a respiratory apparatus, evidenced in the tremulous tags, and which he designated gill-like organs, or gills. His views are represented by the following abstract: "Oval tremulous bodies are in some species, observed attached to a free filament-like tube, generally placed longitudinally within the body, (fig. 416); in some instances, they are attached to the two sexual glands, as in *Hydatina*. Their function is respiratory, and they are analagous to gills; the tremulous motion observable, being that of the lamina composing them. The reception of water within the body, for these organs to act upon, is provided for, by one or more openings at the anterior part of the body, furnished, in some species, by spur-like processes, or tubes."

The annular cords, producing the semblance of articulations in the body of many *Rotatoria*, were surmised by Ehrenberg to be vessels, but, as before stated, the general opinion is that they are muscular. In some examples, he also described the vessels to form a net-work, more or less distinct, below the margin of the mouth, and connected by free longitudinal cords to the interior surface of the body. (pl. ix. fig. 419).

No naturalist has yet confirmed such a vascular network, as is thus figured and described; but various delicate muscular threads are known to cross one another, about the neck of these animals, as they pass to their insertions in the muscular cushions forming the rotary apparatus. Thus, Mr. Gosse says: "threads with bifurcate extremeties go from the centre of the head to each cone-top (of the rotary organ), each lateral eye, and each antenna." Dr. Dobie also speaks

of muscular bands in the same position, passing to the centre of the depressions between the lobes of the head of *Floscularia campanulata*, and of lines of a fainter description, running up the centre of each lobe, to near its apex.

We are enabled to give an independent description of the gill-like apparatus in the neck, from Mr. Gosse's admirable account of the *Asplanchna priodonta*. He writes: "On the upper side of the oviduct sits a contractile bladder, which, when full, is perfectly globular and small; being scarcely, if at all, larger than the two pancreatic glands put together. Round this, attached at or near its base, passes on each side, a tortuous thread, apparently glandular, which goes up along each side of the ventral region, and is attached to the head-mass behind the jaw-cushion. The middle part of each thread is wrinkled into a large plexus of four or five pairs of doublings, laid with some regularity; on this plexus are placed four tremulous tags, directed inwards; making eight in all. None are visible on any other part of the threads. The presence of these organs, as well as of the contractile bladder, in the female, shows that these are not connected with impregnation. Close to each plexus there is a minute orifice in the skin, set around with short setæ, and a similar one is placed on each side of the back, but a little higher up. From each of these four apertures, a thread, floating freely in the cavity of the body, goes towards the head, having, at its contact with the aperture, a thickened club-shaped ganglion or gland."

We have assumed that this description applies to the gill-like, or respiratory apparatus, of Ehrenberg, or the 'water circulating system' of Siebold; for to no other structures can the 'tremulous tags,' and their accompanying 'tortuous threads' of Gosse, in our opinion, refer. Hence, if our assumption be correct, Mr. Gosse appears to believe in the glandular nature, at least of the tortuous threads, of those organs, and thus, in some degree, to countenance the first hypothesis of Ehrenberg, respecting their glandular office; the latter, however, supposed them spermatic glands, or vesiculæ seminales; but as Mr. Gosse remarks, they are evidently not connected with impregnation. The contractile sac which Ehrenberg surmised to be spermatic, Mr. Dalrymple says he is convinced, from repeated observation, has no relation to the generative function; and, as we have seen, attributes

to it a respiratory office. He adds, "The supposed vascular ramifications upon it, are neither more nor less than the muscular fibrillæ by which the contractions are effected."

SECTION XXIII.—*Of the Organs of Sensation and Nervous System of Rotatoria.*—The *Rotatoria* are not considered to possess a true nervous system, but in many of the species, having eyes, there appears one or two masses attached to them, which Ehrenberg thinks are similar to nervous ganglia and nervous fibrillæ. The eyes vary in number; they are usually of a red colour; in some they are placed upon a ganglion, and are freely moveable beneath the transparent superficial envelope of the body.

The visual organs are of small size, but always sharply defined, and, it would appear, invested with a horny capsule in some cases. The firm capsule is observable in *Conochilus, Rotifer, and Philodina.* Dujardin opposes the opinion of the visual character of these red specks in *Rotatoria*, chiefly on account of their not uncommon disappearance in the adult state. But as Siebold remarks, an objection raised on this circumstance is not valid, since a similar phenomenon is known to take place in the adult condition of parasitic Crustacea, the visual character of whose eye-specks or ocelli is not questioned. Moreover the coloured specks in *Rotatoria* are sharply defined, and in some cases at least, furnished with capsules, thus differing totally from the non-capsular, ill-defined pigment masses of *Polygastrica*, called eyes.

It is doubtful, however, Siebold remarks, whether the disproportionately large specks, described as eyes by Ehrenberg, in *Notommata forcipata, Synchæta baltica,* in *Cycloglena* and *Eosphora,* are other than loose aggregations of coloured particles.

The same author says "there is, in *Rotatoria*, a constant group of ganglions in the neck, regarded as the central organ of the nervous system, from which, nerve-cords radiate on all sides." Over this cerebral centre, the organs of vision are seated, and receive from it their special nerve fibres.

The variable relative position of the eyes is determined by that of the ganglions. The position of the former may be on the neck,—*i. e.* posterior to the base of the rotary organs, or on the fore-part of the head, or even in advance of the rotary apparatus.

In the immature and young state of *Eudorina*, of *Melicerta ringens*, and of *Megalotrocha alba*, &c., distinct eyes are present, which, however, disappear with advancing age.

The sense of touch diffused generally over the body, is especially concentrated in the rotary organ, and in the styliform processes or cornua, so frequently produced from it, which may be deemed analogous to the feelers (*antennæ*) of insects. We may presume also that the toe-like processes of the foot or tail are more largely endowed with sensibility.

Mr. Gosse describing the *Asplanchna priodonta*, writes: "Each of the three eyes rests on a mass that appears ganglionic; the clubbed masses at the lateral apertures are probably of the same character; and the interior of the body contains a number of very delicate threads, floating freely in the contained fluid, which have thickened knobs here and there, especially where they anastomose (see fig .")

SECTION XXIV.—*Of the reproductive organs, and the reproduction of Rotatoria.*—The only method of propagation of *Rotatoria* is by ova, of which they deposit only a few at a time. The size of the egg is about 1-36th that of the parent, and the young of those in which incubation is completed before expulsion is sometimes two-thirds.

Although the Rotatorial Infusoria are not endowed with the various faculties of reproduction possessed by the *Polygastrica*, yet their vast increase by eggs only, would astonish most persons who have not considered this subject. Ehrenberg informs us that he insulated a single specimen of *Hydatina senta*, and kept it in a separate vessel for eighteen days, that during this interval it laid four eggs per day, and that these young, at two days old, lay a like number, so that, when circumstances are favourable, one million individuals are obtained from one specimen in ten days; that, on the eleventh day, this brood will amount to four millions, and on the twelfth day to sixteen millions. Although the fecundity of this *Rotatoria* is the greatest that has been tested by direct experiment, yet (says Ehrenberg) in the large *Polygastrica*, as the *Paramecium aurelia*, a single specimen in one day increases to eight, by simple transverse division of the body only; so that, if we take into this account the other modes of the increase of this creature, namely, by eggs, often in masses like the spawn of fish, and again by buds growing from

the sides of the body, it is clear, in a very few days, all attempt at an expression of their number must fail.

The *Rotatoria* have generally been assumed to be hermaphrodite—*i. e.*, that each individual possesses a perfect male and female reproductive apparatus, by which ova are formed and fructified, without the presence or contact of any other individual. Now, in these animals, there has never been any difficulty as to the female reproductive organs, which are very clear, well defined, and can be accurately described, but, as to the male apparatus, the greatest diversity of opinion has existed.

Dujardin attempts no explanation, whilst Siebold candidly affirms, that, with the absence of any precise knowledge as to the male organs, it is still impossible to say whether the *Rotatoria* are hermaphrodite, or have the sexes separate; at the same time, he regards the hypothesis of Ehrenberg on the subject, as untenable, and opposed to probability.

The clearing up of this *questio vexata* is, however, due to our countryman. Mr. Brightwell, of Norwich, from whose discoveries it is rendered highly probable, indeed, in part, certain, that the sexes in *Rotatoria* are separate and distinct—existing in distinct individuals. This careful observer met with a Rotatorial animal, destitute of the internal organization of those heretofore described, but having a very evident gland, communicating by an outlet with the exterior of the body, the latter, moreover, was produced in some measure as a process perforated by the discharging tube. This curious animal, of a smaller size than other *Rotatoria*, Mr. Brightwell was at first disposed to consider another species, but subsequent examinations, and the observation of occasional attachments with the larger and undoubtedly female animals, convinced him, that he had discovered a distinct male animal. Subsequent attention to the subject has confirmed the fact of the diœcious nature of *Rotatoria*; and other observers, besides the discoverer, have witnessed the same phenomenon.

No objection can be raised from the fact of the small size and imperfect organization of the newly discovered male animal, for similar peculiarities are met with among other tribes of lower animals, such as *Annelida*.

This minute male being destitute of organs adapted to continue its own existence, is developed solely for the purpose of impregnating the larger and more highly organized female animal, of which, indeed, it is in part a parasite.

The female reproductive organs consist of a single or double ovary, an ovi-sac, oviduct, and vaginal orifice. The ovary, varies in size, having tubes conducting from it to the cloacal outlet, through which the ova escape. The ovary is situated at the hinder part of the animal, along side the intestine. It is mostly seen to contain ova in different stages of development. The mature ova are invested by a clear, but firm granular shell, mostly coloured, and containing a colourless yolk, with a clear germinal spot. The development of the embryo in the egg, proceeds as in Invertebrata generally, the yolk subdividing by spontaneous fission, and, at length, evolving the embryonic cell. The fully developed embryo is furnished with a rotary organ, eye-spots, an œsophageal head, with its masticatory apparatus, and, in fact, with the entire characteristic organization of the full grown animal.

Mr. Gosse, in his paper on *Asplanchna*, says: "In no specimen have I seen the ovary horned or band-shaped, but roundish and very small."

The ova, after impregnation, pass from the ovary into the ovisac, and there go through various phases of development, like the embryo of higher animals in the uterus. When sufficiently advanced, the young being escapes into the oviduct, which conducts it through the vaginal orifice into the cloaca, whence, after a variable time, it is expelled.

During the residence of the embryo within the ovisac, it mostly becomes enveloped in a shell, of considerable strength and toughness, which preserves it after extrusion from injury. To accommodate the increasing size of the contained ovum, or ova, the ovisac is capable of great distension, so much indeed, that it sometimes occupies the larger portion of the interior of the animal. The cloacal outlet, also, is very extensible, to allow the temporary retention and subsequent passage of the very large matured eggs. In many *Rotatoria*, the ova are not at once set free on their exclusion, but remain adherent about the cloaca, as happens in many *Entomostraca*.

Again it happens in some species, that the egg shell is dispensed with, the embryo being completely developed, so to be able to immediately commence an independent existence on its escape from its parent—in other words, such forms are viviparous: examples are met with in *Philodina, Rotifer,* &c.

Mr. Gosse writes, of the *Asplanchna,* that, "the ovum produces the living young *in the ovisac,* which, when matured, occupies the whole lower part of the parent . . . . At length it escapes through the oviduct and vaginal aperture, and immediately swims freely away."

"The egg of the *Hydatina,*" says Dr. Carpenter, "is extruded from the cloaca within a few hours after the first rudiment of it is visible; and within twelve hours more the shell bursts, and the young animal comes forth . . . . In general, it would seem that, whether the rupture of the egg-membrane takes place before or after the egg has left the body, the germinal mass within it, is developed at once into the form of the young animal, which represents that of its parent; no preliminary metamorphosis being gone through, nor any parts developed which are not to be permanent." (Principles of Physiology, p. 362.)

The first male discovered, was that of *Asplanchna Brightwellii,* then a supposed species of *Notommata,* and is thus described by Mr. Brightwell. (Ann. Nat. Hist. 1848, p. 155.) It is "about half the size of the female, and differs from it in form, being much shorter and of a rude triangular shape. It is more difficult to detect than the female, being exceedingly transparent, and, from the emptiness of the body, appearing little more than a transparent ciliated bubble. It is very active, and occasionally puffs out the sides of its body, so as entirely to alter its form, and remains thus distended some time." There was no indication of any digestive apparatus, or of matters in course of digestion.

"At the bottom of the body on one side, is a conspicuous round sperm vessel or testis, in which, under a high power, spermatozoa, in active vibratile motion, may be seen; and, at its external side a duct, closed by distinct lateral muscles. Connected with the testis, is a well defined intromittent organ, and a conspicuous passage or opening for its extension from the body of the animal. In the

opposite lower angle are three small, irregularly formed, kidney-shaped bodies, connected with an angular lobe or muscle lying beneath them. The male is also furnished with the delicate membranous plicated bag, and rudiments of the curled tubular structure found in the female."

Besides determining the diœcious character of this *Rotatoria*, Mr. Brightwell was also enabled to repeatedly verify the occurrence of an actual coitus occurring between the sexes, and enduring the greater part of a minute.

We append, to this account of the male, some further particulars, derived from Mr. Gosse's paper. On the *Asplanchna priodonta* (Ann. Nat. Hist. 1850.) "The principal muscles agreed with those of the female. The tortuous threads and their plexuses (Section XXII.) were represented by two thickened glandular bodies, extending from the head mass to the foliaceous substance surrounding the sperm bag . . . . The three eyes were present, situated as in the female, but no trace of jaws was discernible, even on pressure, nor any crop, nor true stomach. These animals were very active, swimming rapidly about, and scarcely still an instant. On one or two occasions, I observed one of the males, with a slender process, protruded a considerable length from the sexual orifice, and adhering to the glass by its tip; moving round on it as on a pivot."

Mr. Gosse had the good fortune to witness the development of the males from the ovum. He writes: "I saw the developing young in a pregnant female, that seemed different from the ordinary embryos; and in hope that this might be a male, I isolated the parent;" and Mr. Gosse, at length, had the satisfaction of seeing two males born from this female, of similar outline to the latter, but instead of being 1-48—1-42 of an inch, were only 1-110 of an inch.

Section XXV.—*Of the Affinities and Classification of the Rotatoria.*—That the Rotatorial Animalcules, by their high degree of organization, should be elevated in the animal scale far above the *Polygastrica*, and that they cannot be rightly comprehended with the latter under the general appellation of Infusoria, is now generally admitted, although, as hereafter stated, resemblances do exist. The particular affinities of the *Rotatoria* have not been generally agreed upon, hence, these animals have been differently placed by different

authors in their proposed classifications of Invertebrata. Thus, Burmeister has classed them with *Crustacea;* Wiegmann, Milne Edwards, Wagner, Siebold and others, with *Vermes*. To which of these two classes of *Articulata*, preference is to be given, Siebold observes, is not very questionable, for their affinities, with the *Crustacea*, are but remote, since not only is there an absence of a distinct abdominal membrane, and of striped muscular fibre in *Rotatoria*, but they present, both on their outer and inner surfaces, organs of respiration. Again, the *Rotatoria* emerge from the egg with their form perfect, and without any limbs in pairs; whilst the *Crustacea*, after their birth, undergo metamorphoses, and are furnished with several pairs of extremities. On the other hand, the *Rotatoria* approach the *Vermes* (which include the *Helminthæ*, *Turbellara*, and *Annelida*) by their means of locomotion, their deficiency of limbs, and the lining abdominal membrane.

Mr. Gosse, from his observations of the internal structure of *Rotatoria*, and especially owing to the presence of mandibles, maxillæ, and maxillary palpi, affirms that they have no connexion with the *Radiata*. In this, he coincides with all, or, almost, all naturalists, who would place these animals among the *Articulata*, though with which division of this class is, as we have seen, still a matter of dispute.

M. Doyère at first concurred with M. Dujardin in recognizing an affinity so close with the *Rotatoria* as to class with them the *Tardigrada;* but his subsequent researches have induced M. Doyère to surrender this view, and, whilst admitting an affinity, to keep those two tribes of animals distinct.

Dujardin has remarked, "The *Tardigrada* constitute a passage between the *Systolides* (*Rotatoria*) and the *Helminthidæ* on one side, and the *Annelida* and *Arachnida*, on the other."

We have before had occasion to indicate the affinity between *Vorticellina* and *Rotatoria* in the wreath of cilia about the head; as also to state Dujardin's objections to receiving *Chlætonotus* in the latter class; these circumstances, consequently, prove the alliance of the *Rotatoria* and *Polygastrica*. In some general features, likewise, the two classes approach; as, for instance, in the transparent sheath enclosing the animal of *Vaginicola*, analogous to that in *Floscularia*

and *Stephanoceros;* in the grouping in gelatinous masses of the individuals of *Ophrydium* as compared with that of *Conochilus*. Again, in the tubular sheath of *Melicerta*, with its adherent foreign matter, a resemblance to some *Annelida* is manifested; in the horny partially investing lorica of *Noteus*, *Brachionus*, and other *Rotatoria*, a likeness to the *Entomostraca* is to be found; and, as pointed out already, the long-ciliated arms of *Stephanoceros* find their analogy among the *Ciliobrachiate Polypes*.

In the classification of the *Rotatoria*, Ehrenberg was chiefly guided by the character of the rotary apparatus—according as it formed a continuous circle or wheel, when he termed it *Monotrocha*, or was divided into two or more segments, which he named it *Sorotrocha*. Proceeding on the same plan, he subdivided each of these primary divisions into two sections; the first, into *Holotrocha* and *Schizotrocha;* the second, into *Polytrocha* and *Zygotrocha*. (See Part III., class *Rotatoria*.)

Siebold and others adopt this arrangement, but, at the same time, declare it defective and artificial. Mr. Gosse has employed it as the most convenient yet published, but, as we are glad to see, promises an arrangement more according to the organization and the natural affinities of its members." (Ann. Nat. Hist. v. viii. p. 197.)

In the further distribution into families, Ehrenberg has recourse to the character of the surface, whether this be loricated, or illoricated. But the use of these terms, after this manner, in the case of the *Rotatoria*, is objectionable; for, as M. Dujardin remarks, "all the *Rotatoria* are clothed by a resistant integument," and hence "Ehrenberg is compelled, sometimes, to call a thicker and harder portion of the common integument, the lorica; at other times, to apply the word to a diaphanous tube, or to the mucilaginous secretion enveloping in part the *Lacinularia*, or to the sheath of *Melicerta*, which is evidently a secretion with agglutinated foreign particles."

In the construction of genera, Ehrenberg has been guided chiefly by the variations in the number and disposition of the eyes. To this, Dujardin also objects, for, says he, "since the eyes may disappear, from circumstances of age, or of development, the employment of this character, will place in different genera *Rotatoria*, which are but varieties of the same species."

Siebold adopts the genera, but not the families of Ehrenberg, and Dujardin devises a temporary distribution of *Rotatoria*, according to their varieties of locomotion; and, including the *Tardigrada*, thus makes four divisions :—1. Those which live fixed by their posterior extremity. 2. Those having but one mode of locomotion by means of their vibratile cilia, and which are all swimmers (*nageurs*.) 3. Those which have two sorts of movement, one of crawling (*rampants*) after the manner of leeches, the other of swimming, like the previous forms. 4. Those destitute of vibratile cilia, but provided with aculei or claws (ougles) and which are true creepers (*marcheurs*).

The last division (*marcheurs*) has but one family viz. *Tardigrada;* the third but one also, viz.—*Rotifera;* the first two families, the *Flosculariens* and *Melicertiens;* whilst the second is separable into two sections, *Brachioniens* and *Furculariens*, each representing numerous genera.

Owing to the absence of silica or lime in the integument of *Rotatoria*, and its consequently perishable nature, these animals do not occur in a fossil state.

The *Rotatoria* are distributed over every part of the world; the special or limited geographical distribution of genera, we have, at present, no data to determine.

Section XXVI. — *On Showers of Infusorial Animalcules.*—In ancient and modern times, storms or showers of solid bodies have occasionally been observed. The dust which falls upon the earth, when of a red colour, has been compared to blood; and in Egypt, where little or no rain falls, the superstitious inhabitants have been much alarmed when such an event has happened. Professor Ehrenberg, in a work now before me, entitled *Passat-Staub und Blut-Regen*, referred to at page 65, has, with the characteristic energy and perseverance of his country, investigated this subject very minutely, and I propose here, to give some of the results of his research.

The memoir occupies 192 folio pages besides tables, and is accompanied by six large plates.

The quantity of actual solid matter that has fallen from the atmosphere by showers, is far more considerable than might be imagined, for though it falls in a divided dust-like mass, the extent of surface which it covers is large. Comparing it with Meteorilites, Ehrenberg

observes, that from 1790 to 1819, there fell of the latter, stones whose weight amounted to 600 cwt., while in a single dust shower at Lyons in 1846, the material weighed full 7200 cwt. Other storms of dust in Italy, at Cape Verd, and other places, have even exceeded that at Lyons, in the amount of solid matter which fell on the earth, and Ehrenberg asks, how many millions of tons weight of microscopic organisms have reached the earth since the time of Homer. He adds, "I cannot longer doubt, that there are relations according to which living organisms may develope themselves in the air."

He supposes the atmospheric dust cloud region is of vast extent, and at a height of more than 14000 feet. Ehrenberg considers these phenomena cannot be traced to mineral substances from the earth, nor to revolving masses of dust material in space, nor simply to atmospherical currents, but to some general law connected with the earth's atmosphere, according to which, there is a self-development within it of living organisms.

The following are selected from the showers of Infusorial organisms recorded:—

1. In the Atlantic, latitude 17° 43′ N. and longitude 26° W. about 500 miles from the coast of Africa, the dust, as it fell, was collected by Mr. Darwin, from the deck of the ship. The wind at the time being from the coast. It resembled ashes. On examination, one-sixth of it consisted of the silicious fresh water Infusoria and Phytolites—18 species of each. Most of them were European, and none exclusively African. Also a South American species, *Surirella Peruviana*, and the *Himantidium papilio*. The inference formed by Ehrenberg is, that this shower came from the upper regions of the air from South America, otherwise those species are yet to be discovered in other countries.

2. Dust from other showers in the Atlantic were collected by the same naturalist, between the years 1834 and 1838. These collections contain 30 additional forms of Infusoria, also the two species above named. Three of the species of *Eunotia* have only been met with in Senegambia and Guiana, also the South American *Amphidiscus obtusus*. No species peculiarly African was found in any of the dust.

3. Dust from Malta, which fell on May 15, 1830, contained 43

species of organisms, of which 15 were Infusorial. Some of these species occur in Africa, yet none peculiar to that country. This is remarkable, as those showers with the hot winds, which accompany them, are said to come from the Sahara Desert, which must be erroneous. Among the species were a Chili one, *Synedra entomon.*

4. Sirocco dust from Genoa, May 16, 1846, contained 22 species of Polygastric Infusoria, 21 of Phytolitharia, and three fragments of plants. The colour is yellowish from oxide of iron, not grey like African dust, and one-sixth to one-third of its weight was organic. Ehrenberg remarks that these results show that the showers of dust from the Atlantic, Malta, and Genoa, are alike, and also exhibit an absence of true African forms.

5. Sirocco dust from Lyons, October 17, 1846, contains 39 species of Polygastrica, 25 Phytolitharia, and 3 Polythalmia. The organic matter forms one-eighth of the mass, and is mostly from inhabitants of fresh water.

Nine showers of dust from the above localities, gives in the whole, 57 species of Polygastrica; 46 Phytolitharia, and 8 Polythalmia. Besides 7 kinds of plants and fragments of an insect. Of marine species there are 17. Fresh water 102. There is no evidence of volcanic origin.

6. May 16, 1846. A second shower, on the same day at Genoa, gave nearly the same species.

7. Storm of red snow in Puster Valley, in the Tyrol, March 31, 1847, contained 22 species of Infusoria and an insect, besides 30 species of other organisms. Ehrenberg remarks the uniformity of character of the dust over regions so widely separate, yet in nearly a common latitude or zone, and in so many distinct examples through a number of years is most surprising.

8. In dust which fell in Italy 1803, and in Calabria in 1813, the first contained 49 species, the latter 64. In both, all the species are of fresh water habit, and one-fourth of them similar. The most abundant were *Eunotia amphioxys*, four species of *Gallionella*, viz.—*granulata*, *crenata*, *distans*, and *procera*. In both also were four South American forms; *Coscinodiscus flavicans* from Peru and St. Domingo; *Navicula undosa* from Surinam; *Stauroneis linearis* from Chili and

North America; *Synedra entomon* from Chili. The last occurs in Africa and Asia, but none were peculiar to Africa.

Other facts of storms of dust are recorded by Ehrenberg. Red hail was observed by Humboldt in Paramo, between Bogota and Papayan, at a height of 14,700 feet.

On October 14, 1755, at Lacarno, near Lago Maggiora. At 10 o'clock in the morning a red mist filled the air, and at 4 o'clock in the afternoon there was a blood-rain, which left a red deposit covering 40 square German miles. At the same time a reddish snow fell upon the Alps. It is calculated that each English square mile received a deposit of 2700 cubic feet.

In 1623 blood-rain fell at Strasburgh, and in 1222 a similar event happened at Rome. Ehrenberg records 340 showers of blood-rain and dust-rain—81 before Christ, commencing with the time of Moses in Egypt, and 259 after. (See Edin. Phil. Jour. 1852.)

Notice.—The reader is referred to the appendix, for Professor Ehrenberg's reply to the observations of naturalists opposed to his views, of the animal nature of the doubtful Infusoria.

End of Part I.

PART II.

ON THE COLLECTING AND PREPARING

INFUSORIAL ANIMALCULES

FOR

Microscopical Examination.

Section I.—*On the Method of Capturing, Selecting, and Placing Infusoria for Examination under the Microscope.*—To procure specimens of Infusoria for examination and study, no expensive apparatus is necessary, a few common wide-mouthed phials are sufficient—those containing about four ounces a piece will be found most suitable—let them be fitted with proper corks, and not with glass stoppers. Some persons insert a piece of quil into the cork to give the creatures air. I have not found this necessary, but always remove the cork when I arrive at home. If it be required to have all the tackle neatly arranged, they may be put into a small tin case, expressly constructed for the purpose, and each bottle separately marked. In place of phials, however, cylindrical glass vessels, from three to five inches long, may be substituted, as they will lay better in the case, which need not exceed the dimensions of a common sandwich-box. A good walking-stick, with a hook at the end of it, and a piece of twine, should always form part of the equipment. As the margin of small ponds is sometimes difficult of near approach, I have contrived a spring-hook, which is attached to a moveable ferule, and made to fasten to the end of the walking-stick. This lays hold of the phial, and enables you to charge it from the surface of the water, in the immediate vicinity of the stalks of water-plants, a situation generally abounding with Infusoria.

Various ingenious contrivances have been invented for the same purpose since the above was published, but, as most persons would be induced to adopt such a plan as would best suit themselves, it will be unnecessary to describe these contrivances in detail. I may only

observe that those persons whom I have found the most successful in these matters, always employ the cheapest and simplest contrivances.

For the larger kinds of Infusoria, and especially those living upon aquatic plants floating on the surface of the water, a small net is very useful. I have for many years used one made as follows: Take a piece of common iron wire about $2\frac{1}{2}$ feet long and $\frac{1}{8}$th thick, bend one end into a round hoop about three or four inches in diameter, and turn the other end into a small loop for the handle. Take a piece of fine Irish linen and make it into a bag, either pointed at the end like that shown at page 51 of the "*Microscopic Illustrations*," or rounded. This bag, when sewed on to the iron hoop, forms the most convenient appliance I have met with, and may be carried about in the coat pocket. Another appliance which I find of great use, is a small white saucer for the purpose of skimming the water. By this means, numerous kinds of Infusoria, which attach themselves to floating plants, may be captured readily, and then transferred to a phial.

Take with you, also, a pocket magnifier, of shallow power. This may be mounted in various ways; but the one I prefer is a triple one, having the lenses arranged in the same plane; the convenience of which is, that you will have three different powers always ready for use, without the necessity of moving them; and that, the mounting being flat, it will be very suitable for the waistcoat pocket. Sling this, with a piece of ribbon, about the neck, and there will be no danger of losing it. The magnifying powers usually selected, are those from five to fifty diameters (2 inches to $\frac{1}{2}$ an inch focus); the first, or largest, serving to distinguish the masses; the intermediate, to show the general movements, so as to determine pretty nearly whether the water you have collected is worth retaining or not; and the smallest, or most powerful, for examining the contents with more minuteness. This latter power will not so frequently be called into use abroad as at home; because, with a little practice, the middle and shallow powers will be found to answer every purpose.

The grooved sphere (see Treatise on Optical Instruments, 1828,) now called the 'Coddington lens,' is, when mounted, a very excellent magnifier for these purposes, as in every position the rays traverse the axis; but by far the best for definition, is an inverted

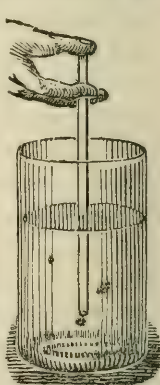
Huyghean eye piece of short focus, that is, having lenses of $\frac{3}{8}$ and $\frac{3}{4}$ of an inch focus.

Again a white saucer offers the best means of examining the water in a cursory manner, to ascertain whether the pool contains the animalcules you desire.

Being equipped with the needful appliances—a few phials, a small cloth net, a white saucer, a white cambric pocket handkerchief, on which to place water plants to drain, and a magnifier. The sportsman should provide himself with a stout pair of boots, for I can assure him, if he enters heartily into his sport, he will sometimes find himself ancle deep in water in beating about for choice specimens. Proceed to the nearest ponds of water in the neighbourhood, and should there be healthy Lemnæ on their surface, or Confervæ, or other aquatic plants, you will be almost certain to meet with animalcules. If there be any drains, however, communicating with them, the chances are that they contain only the common species, which will, by a little practice, be readily distinguished by their motion, general appearance, and colour. The indications of the presence of Infusoria are specks moving about in the water, or an apparent mouldiness around the stalks of the Lemnæ, &c. Should these appearances not be discerned under the middle power of your magnifier, throw away the water, and repair to some more favoured pool. Be careful to take only a small portion of the vegetable matter in your vessel, as its decay, and the consequent evolution of gas, may soon kill all your animalcules. This must be constantly borne in mind. Clear pools of water, in the spring of the year, are the favourite places of resort for the *Volvox globator;* clear water, slowly running in clay or chalky soils, for the *Bacillaria* and *Arcellina.* House gutters, and tubes placed to receive the rain water, often contain a rich supply of the *Rotifer.* In the winter, you may search for animalcules in water among dead leaves, reeds, &c., which may be taken out, and their contents shaken off into clear water; while the species which attach themselves firmly to these objects may be examined without their being removed from them. On approaching a pond, always observe the direction of the wind. On the leeward side you will find floating aquatic plants congregated, as also a scum of organic matter, this will furnish an abundant "take" of Infusoria; while, to the windward side, you may obtain different kinds and less

numerous. Dr. Ehrenberg states that he has met with good success in the winter under bridges, around the piers and outworks, and even in frozen ditches beneath the ice. When you have filled your vessels, cork them carefully, so as to exclude the air, for the shaking in the carriage, when a quantity of air is left in the vessels, will often destroy them before you arrive at your place of destination. In this respect, my mode of proceeding differs from that of Dr. Ehrenberg, who always leaves a small proportion of air in the vessel; judging, therefore, from my own experience, I should conclude that he is more careful than myself as to their conveyance. The only inconvenience I have experienced from keeping the vessels entirely filled with water, during the short time of transporting them home, has arisen from those creatures which appear to live on the surface, as *Euglena*, &c., attaching themselves to the cork, and remaining so when required to be taken out. Remove the corks as soon as you get home, and place the vessels upright; for which a mahogany stand, furnished with a number of holes adapted for the vessels, will be very convenient. A gauze covering, fitted to the frame, will keep out the dust and blacks, without obstructing the free ingress of air.

We now proceed to the mode of investigating these minute creatures under the microscope. If the kind to be examined are those which swim freely, and are visible to the naked eye, as the *Volvox*, *Bursaria*, and other large *Polygastrica*, and also the free *Rotatoria*, take a small open glass tube, such as is described in the *Microscopic Cabinet*, p. 236, (edition 1832) and select the specimens with it in the manner there recommended. The figure of the tube I here insert from that work. The diameters of these tubes may vary from one-eighth to one-twelfth of an inch, and their length from four to eight inches. It may be useful occasionally to draw out and slightly bend the extremities which are to be immersed in the water.



When the creatures are more minute than those above mentioned, pour a little water from the vessel containing them into a watch glass, and place it upon a piece of cardboard, coloured half *black* and half *white*. The white ground will make the dark specimens apparent,

and *vice versâ;* thus, the required specimens may be taken out singly with one of the tubes, and placed in the aquatic live-box for observation. The observer will derive much assistance in this operation from the use of the pocket-magnifier before mentioned, or from a watchmaker's eye-glass and stand.

When the Infusoria are extremely minute, they usually congregate at the edge of the water over the white portion of the cardboard, and may be removed from thence with the point of a quill, or of a small wedged-shaped pencil. If a quantity of the Chara, or other aquatic plants, be put into a glass jar with the Infusoria, in the course of a few days, more or less depending upon the temperature of the season, the surface will be covered with a thin pellicle, formed by the decomposition and extrication of gas, causing the small detached pieces of vegetable matter to float upon the water, and with them the Infusoria. Let a small portion of this film be taken from the surface, by means of the feeding pin, drawn in the margin, and examined under the microscope, and you will hardly fail of being highly gratified. Among the most interesting genera collected from the surface of these infusions, in the manner just stated, are those belonging to the families *Vorticellina*, *Arcellina*, and *Astasiæa*. After the film has remained some days upon the water, many of the above-mentioned genera disappear, and are succeeded by those of the family *Vibrionia*, especially the *Bacterium*. These, however, may be easily overlooked; for they merely resemble, even under a power of 250 diameters, sintillations, or the vibrations of cilia, among the vegetable matter. But when carefully examined under a higher power, they will appear like so many small short jointed rods, each rod, or chain, having a distinct movement of its own.

When it is desirable to keep living Infusoria, it is necessary to examine the vessels in which they are, every day or two, to ascertain whether they contain any *Entomostracea*, or larvæ of insects, as they feed upon the animalcules, and thus your choice specimens will be destroyed. From time to time, as these appear, remove them. It may happen that, at first, the water may not contain them, but only their eggs, which, in a few days, may be hatched, and the young

destroy all your Infusoria. It is also advisable to keep in the vessel a small quantity of the aquatic vegetation, from among which, you have obtained your specimens. Be careful not to have much, and keep it in a healthy condition. Mr. Varley recommends keeping a small flat water snail in the water, which, he states, feeds upon confervæ and keeps the water sweet.

It is usual to give a list of places where Infusoria may be found, but, as some kind or other may be met with in nearly every locality, it is almost useless to insert one, while those ponds possessing certain species, in a few years change, and are no longer to be found in the same places. To illustrate this, I may mention that some years ago, when preparing for my Natural History of Animalcules, I found the most prolific locality around London, was Hampstead; and, accordingly, in the summer of 1833, I took a cottage there, to be near the ponds. In some I found beautiful species of the *Euglena* and allied genera, in great abundance, for some years they gradually decreased, and last summer the same ponds I found destitute of that genus.

The beautiful organisms known under the name of *Desmidieæ*, which form one of the sections of the family *Bacillaria*, and represented, magnified, in Plates II and XIII, are rarely collected in streams, being unattached. In clear shallow pools, on moors and in boggy places, they are generally abundant in summer. They are rarely found in shady woods or deep ditches. To search for them in turbid waters is useless. M. de Brébisson states that, in the calcareous districts around him (Falaise, Normandy) in which the *Naviculacea* abound, *Desmidieæ* are rare. In the water the filamentous species resemble the Zygnema, but their green colour is paler and more opaque. When they occur in large numbers, they may be taken up in the hollow of the hand; but, when diffused, Mr. Ralfs takes a piece of linen about the size of a pocket handkerchief, lays it on the ground in the form of a bag, and then, by the aid of a tin box, scoops up the water and strains it through the bag. The larger species of *Euastrum*, *Micrasterias*, *Closterium*, &c., are generally at the bottom of the pool, either spread out as a thin gelatinous stratum, or collected into finger-like tufts. If the finger be gently passed between them, they will rise to the surface in little masses, and, with care, can be removed and

strained. At first, nothing appears on the linen except a mere stain, but, by repeating the operation, a considerable quantity will be obtained. If not very gelatinous, the water passes freely through the linen, from which the specimens can be scraped with a knife; if otherwise, the water must be poured directly into the collecting bottle, as force would destroy them. Some species of *Staurastrum*, *Pediastrum*, &c., form a greenish dirty cloud upon the stems and leaves of aquatic plants—to collect these, require much care; the slightest touch will often break up and disperse them. To secure them, let the hand be passed into the water and beneath the cloud, the palm upwards and the fingers apart, so that the leaves or stems of the invested plant may lie between them, and as near the palm as possible; then close the fingers, and keeping the hand in the same position, but concave, draw it cautiously towards the surface, when, if the plant has been allowed to slip easily, and with an equable movement through the fingers, the *Desmidieæ*, in this way, brush off, and will be found lying in the palm. The greatest difficulty is in withdrawing the hand from the surface of the water, and, probably, but little will be retained at first; practice, however, will soon render the operation easy and successful.

The reproductive bodies, or Sporangia of *Desmidieæ*, are collected more frequently by the last than the preceding methods. When your bottles are carried home, they will, apparently, contain only foul water, but, if it remain undisturbed for a few hours, the *Desmidieæ* will sink to the bottom, and most of the water may then be poured off. If a little fresh water be added occasionally to replace that which has been drawn off, and the bottle be exposed to the light of the sun, the *Desmidieæ* will remain unaltered for a long time. Mr. Ralfs mentions he has, in this way, kept specimens of *Euastrum insigne* in good order for five months. (Abridged from Mr. Ralfs' introduction to British Desmidieæ, p. 37.)

Special instructions where necessary for collecting certain families of Infusoria, will be found in the general remarks prefixed to them in Part III.

SECTION II.—*On Microscopes for Examinining Infusoria.*—A good microscope cannot be fully appreciated until it is brought to the examination of living Infusoria. It is true, that we may make use

of the scales of insects and other similar objects as *tests*—nay, even certain shells of *Bacillaria*, the most difficult of *test objects* (Plates XIX, XX.)—we may see with wonder the different markings on the surface of these dust-like atoms, but our admiration will be carried still higher, by the development of those brilliant colours and delicate tints which are discoverable in many species of the minute Infusoria. The criterion of a good microscope, then, will be, that not only the forms of these little creatures, their curious structures, organization, and digestive apparatus, are exhibited with perfect clearness, but that there is also shown the deep and brilliant colouring of their visual organs, and the delicate tints of their variable, retractile, and locomotive processes.

The various methods of managing the microscope, and the different apparatus subsidiary to it, have been so fully expatiated upon by the late Dr. Goring, my much esteemed colleague, and myself, in our joint works, *Microscopic Illustrations*, *Microscopic Cabinet*, *Micrographia, &c.*, that it will only be necessary here to notice, briefly, a few particulars, which more especially relate to the subject before us, and to refer the reader to those works for further information. As the expense of instruments, in the commencement of our studies, is often an important consideration, a few words on this head may not be considered inappropriate, on this occasion. Dr. Ehrenberg informs us, that he began his observations with a common microscope, and, although by his superior talent and unwearied labour, he was enabled to make some important discoveries, yet he delayed, for some years, the publication of them, until he could verify them with better instruments.

At the period when our first publication was announced (1827) an interest in microscopic science had to be created, to which I may add, that the achromatic microscope was then in its infancy, Dr. Goring having only a short time previous (1824) discovered the conditions on which their efficacy depended, namely, *large angular aperture free from aberration.* That publication aroused the attention of scientific men to the subject, but instruments, even such as those then made, were very difficult to procure. To obviate this difficulty, Dr. Goring and myself determined on presenting the public with detailed methods of constructing and testing achromatic microscopes. I further directed

the attention of my workmen to the subject, and gave them, from time to time, such information, as, with their skill and perseverance, might advance them in this branch of art, and I believe, up to the present time, the only successful artists in this country are those who have been in my employ.

In cases where an achromatic microscope cannot be procured, recourse should be had to single lenses or doublets, for the ordinary compound, however well constructed, cannot be depended upon.

With respect to the cost of an effective microscope, with a moderate equipment of apparatus, such for example as the one described in the 6th chapter of the *Microscopic Illustrations*, with its recent improvements, the price would now be from 20 to 50 guineas. As there are a great many persons who require only a plain, sound instrument, of more moderate cost, I have deemed it expedient to take this also into consideration, and, after much application and repeated experiments, have at length produced one, in every way suitable to the case. Such is my "miniature achromatic microscope.' It may be stated that nine-tenths of the observations recorded in this work may be repeated and tested by this microscope. On comparing the above instruments with that used by Ehrenberg, there is no doubt that, in point of mechanical construction, they are greatly superior, whilst the optical part is equal to any with which his researches have been made.

My experience induces me to recommend to all who wish to study this subject, two microscopes—the one a small vertical one with a little achromatic body. The construction which I prefer, is similar to that drawn and described in the *Microscopic Cabinet*, page 243. The stage is circular and the body is about four inches long, it is usually known as the "Miniature Achromatic Microscope," its piece, with an object glass of one-seventh of an inch focus, is five guineas. This instrument I find preferable, in the first examination of an object, to a larger and more expensive microscope, while in travelling its portability is a strong recommendation. Its defects are, that you cannot use a low magnifier with the achromatic body, but this is of little moment, as a few single or doublet magnifiers will always compensate for it. As many persons may think such an instrument a mere toy, I can assure them, that with the addition of a powerful

object-glass, and placing the mirror on one side so as to obtain oblique light, I have seen, on a clear day, and without any trouble or any complex apparatus, most of the difficult lines and dots on the shells of the *Navicula*, such as those represented in Plates XIX and XX.

I am fully aware that a microscope may be too small for real work, but the opposite extreme, too often exists now, and where an observer can have recourse to two microscopes, he will always find it preferable to making one do all the work.

Whether the examination of Infusoria be for the purpose of amusement or investigation, the proper illumination of them is of much importance; in the first place, improper illumination not only prevents an agreeable view to be obtained, but greatly fatigues and injures the eye; while, for the investigation of the true structure of an organism, the proper illumination is of vast moment. The different methods of illuminations may be enumerated as follows: 1st. *Direct light*—either simple, or condensed and unrestricted, or restricted by diaphragms or stops. 2nd. *Oblique illumination*—either simple or condensed. 3rd. *The black ground illumination.*

Black ground illumination. The original account of this plan will be found in the *Micrographia* published in 1834. Since then it has been variously adapted. The simplest plan is to place the mirror out of the axis, and to direct the light from the mirror so as to illuminate the field of view, and by gently turning it (while looking through the microscope) until the object only is bright. In this simple way many animalcules are seen to advantage. I have before me some specimens of the *Volvox globator*, prepared in 1841, which are shown in this way to great advantage.

The muscular fibres of the *Rotatoria*, and the markings on the lorica of the *Bacillaria*, &c., are brought out in a most remarkable manner by this mode of illumination. For an account of the method of examining objects in this way, see the Rev. Mr. Reade's paper in the *Micrographia*.

Some observers disapprove of the use of candle or lamp light, on account of its colour, and consider clear day light can alone show an object properly. As, however, artificial light is sometimes unavoidable, it has been proposed to obtain white light, by passing the yellow rays from a candle through blue glass, or such media as will

neutralize the yellow. To obtain the correct tint of blue for this purpose, it has been proposed to select a crystal, which, by polarized light, gave the exact yellow tint of the candle, and then, by turning the polarizer a quarter round, you have the crystal of the exact blue required.

This method of sifting the light, leaves for use only so much from the candle as is imperfectly monochromatic, which, I am inclined to think, is too feeble. Observers should bear in mind the results of the observations in the *Microscopic Illustrations*, on this subject, namely, that a pure *intense* light is far more important than *quantity*.

In viewing live animalcules, it will be well to be provided with diaphragms or stops to place under your object. By the employment of these, you will the more readily be able to detect cilia, also their arrangement and the currents in the water produced by cilia. In viewing the striæ on the lorica of the *Bacillaria*, stops or diaphragms must not be used. In general, oblique light is best to demonstrate their existence. When Dr. Goring and myself were first engaged upon *test objects*, it was laid down by us as an axiom, that all lined objects required oblique light. Subsequent improvements made in consequence of our pointing out the value of angular aperture (unknown until Dr. Goring discovered it) enabled microscopic observers to see the lined *tests* of those days with direct light. This induced some observers to deride the idea that oblique light was at all necessary. The recent discovery of more difficult tests, viz., the minute shells of certain *Naviculæ*, has shown that, even with our most improved achromatic microscopes, it is necessary, nay, so ticklish a thing is the illumination, that I am informed that those who make the structure of these shells a special study, require 40 or 50 minutes manipulation with a first rate instrument, and all the modern ingenious appliances for obtaining intense oblique light, before they can show certain striæ or dots on a well-known specimen.

While treating of oblique illumination, I may mention that, if artists can produce object-glasses of increased angular aperture, it is probable we may commence another cycle in our modes of observation, and then view all the present difficult *tests* with central light. Mr. Johnson, of New York, states that such has been done by Mr. Spencer, who has produced an object glass of one-twelfth of an inch focus and 147° of clear aperture. However, so long as oblique light

is necessary, I would recommend observers, when requiring it of great intensity, to employ *reflection* for condensation, and not obtain their condensation by *refraction*. On this account I prefer the ingenious parabolic reflector of Mr. Wenham (see *Micrographia*, p. 88. fig. 8), or the same in solid glass as contrived by Mr. Shadbold. The beautiful oblique prism of M. Natchet, has many useful properties, still on principle all condensation by refraction should be avoided. When the construction of the microscope will admit of a wax taper to be placed close behind the object, which those described in the "Microscopic Illustrations" do, very pure vision is obtained.

Another point of some importance in the examination and verification of striated objects is the power of making them revolve in the axis of the optical part of the microscope. This is effected both in Dr. Gorings Engiscope and in mine. To obtain this purpose, it is necessary that the moveable stage be attached to a fixed ring, so that the motions, however eccentric they may place the slides, shall always keep the object in the centre of revolution.

For viewing animalcules in phials or glass tubes, there is no method so good as that of placing the phial itself in the spring phial holder, having first turned the microscope on its side, as shown in the *Microscopic Illustrations*, figure 21. A microscope that has not the necessary motion for this purpose, cannot do its work effectually, therefore all large instruments should possess it.

In a large microscope, which is a great luxury always to have at hand, I find it advisable to have it equipped with two achromatic bodies—a large body for shallow magnifying powers, and a small one for high powers.

The magnifying powers of a *complete* microscope for perfectly examining *all* kinds of Infusoria should range from 50 to 1000 diameters; and as this cannot be obtained with first-rate glasses, without recourse being had to several sets, such an instrument would be necessarily expensive. The microscope first mentioned has two or three sets of glasses, varying from 35 to 800; and the second, one set, from 100 to 250 diameters; so that, as before stated, all the most interesting observations on Infusoria may be conducted with either of these instruments, whilst additional sets may be obtained as occasion requires.

It is important to notice, that in all cases where the magnifying

powers of microscopes are spoken of, the standard of sight used in computing them should be known, otherwise very erroneous ideas will be formed. In all my publications, from 1827 up to the present time, reference has been had to a *ten inch standard*, and the enumeration of powers has been in *diameters*, or what are sometimes termed *linear*; thus, what I compute at 100 is often spoken of as 10,000, that being the superficial measurement, ample reasons for the adoption of *linear measure*, and of that standard, are given in my works on this subject.

In demonstrating minute portions of the structures of Infusoria, a power of 800 diameters will sometimes be requisite, unless the sight be exceedingly good. I have invariably observed that aged persons require greater assistance, in this respect, than young ones. Notwithstanding this, it will be impossible to arrive at an accurate knowledge of the creature you may be studying, even with a power of 800, unless it has been previously examined under a lower one, so that the relations of its several parts may be first clearly understood. Whenever the object in view is merely that of instructive amusement, a power of 250 diameters will be amply sufficient; that power can be managed with ease, and does not fatigue the observer. The greater number of Ehrenberg's discoveries were effected under a power of 380. I am not aware whether he has mentioned in any of his works the sidereal focal length of his object-glasses, or the standard of sight. The set which Dr. E. speaks most in praise of is similar to one which I employ, and which has a focus of 1-7th of an inch. He considers that with "a good achromatic microscope and a lamp, our observations may be carried on at night as well as in the day, which, by some, may be esteemed an additional recommendation." (For further information on the illumination of Infusoria, see Part III, *Bacillaria*.)

Section III.—*On Micrometers, and the Method of Measuring Infusoria.*—The late Dr. Goring, in the *Micrographia*, has described the method by which, in various ways, a correct admeasurement may be taken of these minute creatures, as also Mr. Bauer, in a paper in the same publication. I cannot do better than refer the reader to these authorities, for the fullest information attainable on this subject. A few words, however, may be said on the mode of proceeding, which I have myself adopted, and which, after much practice, has been

productive of very accurate results. It is as follows :—Having set up the microscope and screwed in or adapted the glasses which are intended to be used, take a glass micrometer, and place it on the stage in the same manner as if it were an object to be viewed, then carefully adjust the focus of your instrument, so that the *lines* on the micrometer may appear quite sharp and distinct. Next, take a common ruler, or a slip of card-board with equal divisions of some known measurement drawn upon it, every tenth division being longer than the rest, and fix it 20 inches from the eye, whilst looking through the microscope; then, whilst one eye is directed to the rule or card-board, and the other to the lines of the micrometer, seen in the microscope, ascertain how many on the card are equal to a given number on the micrometer. If the divisions on the latter be 1-100th of an inch, and one of them be equal to ten on the card, it is clear that every division on the card will represent 1-1000th of an inch. Thus, when the micrometer shall be removed, and an animalcule be put into its place, if the creature subtend five divisions on the card, its size in linear measure will be 5-1000th of an inch. Note—The glasses must not be changed during the experiment, nor their distances apart; neither must the distance between the card and the eye be in any way altered.

Section IV.—*On Glass Tubes, &c., for taking Infusoria from the Water, and placing them in the Apparatus for examination.*—As these useful little contrivances, (which have been before alluded to in page 96) are drawn and described by me in the *Microscopic Cabinet* in 1832, it will be necessary merely to mention that little or no improvement has been made upon them since that period, excepting perhaps that a *finer* description is found to answer the purpose better than when the larger ones are drawn out at their extremities in the manner there proposed. The reader will find figures and descriptions of several useful little contrivances in a work entitled "*Microscopic Objects—animal, vegetable, and mineral.*"

Section V.—*On the Compressor, or Crush Box.*—The last remark is equally applicable to the Aquatic-live-boxes, which were described in the *Illustrations*, 1828, and subsequently their different modifications. In order to form an idea of a compressor, or crush-box, you must suppose that the cover of the live-box is so adapted to its box

by a screw, or some other convenient means, as that a small body placed under it may receive a certain degree of pressure without its parts being dislocated. In my original live-boxes, this was effected by a screw being attached to the cover; but, in the ordinary way, the cover is made to revolve. In some, I have substituted a guide-piece for the screw, so that the pressure is obtained without the glass-plates sliding one upon the other. The German opticians attach the cover or upper plate to a jointed lever, at the longest end of which a screw is applied, which brings the upper plate connected with the short-arm, in contact with the lower plate. The use of the crush-box is to protrude certain parts of the animalcule for examination by pressing down upon the creature. In this manner, the teeth of the *Rotatoria* become distinct. Other uses of this apparatus are given when speaking of the minute loricated *Polygastrica.*

I have lately employed with very great advantage, in place of the Aquatic live-box, an apparatus which is peculiarly suited for viewing living Infusoria. It combines the use of a live-box and compressor, and may not inappropriately be called *an Aquatic plate.* It is composed of a stout plate of glass, the size of a common slide. Over this, is a moveable plate of brass, with a spring fixed to it, and a *thin* disc of glass in the centre, to cover the object. The two plates are connected by two screws—one to hold them together, the other for adjustment of distance. I am indebted to Mr. Wenham for the original idea which I have improved upon.

SECTION VI.—*On Viewing Infusoria by Polarised Light.*—Having, in the last edition of the *Microscopic Illustrations,* given a full description of the Polarising Microscope, and the apparatus necessary for using any microscope for polarising purposes, a very few remarks on the effects produced by viewing Infusoria under this light will be sufficient here.

The siliceous covering of Infusoria is but slightly affected by polarised light: that the effect is only feeble, is attributable to the extreme tenuity of their shells, for could we but contrive the means of magnifying the effect, I feel convinced that some very important results would be obtained. The ribs or striæ on the *Navicula,* assume a slight tinge of colouring when the polariser and analyser are parallel to each other; but when they are crossed, owing to the few

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rays which are transmitted, I was unable to perceive it. *Isthmia* are slightly influenced by polarised light. The larger Infusoria I have not examined, nor am I aware that any information is recorded on this subject.

SECTION VII.—*On the Method of Feeding Infusoria with Coloured Substances.*—Select for this purpose such coloured substances as are entirely free from metallic oxides, and not chemically soluble in water. They must, however, be capable of a very minute mechanical division. The substances generally used are carmine, indigo, and sap-green, the first being preferable. This material should be as pure as possible. Take a piece or cake of it, and rub the corner once or twice on the stage-glass, or what perhaps is better, the lower plate of an aquatic live-box, having first moistened it with a drop of water. The colour requisite for the purpose is very small—only just sufficient to render it appreciable to the naked eye—for if there be too much, the probability is, that the particles will be too large for the creatures to imbibe. Having thus prepared the coloured food, place a drop of it beside a drop of the water containing the animalcules, but not so that they may come into contact; then put on gently the cover of the live-box, and lower it sufficiently to flatten the two drops of fluid, but not to force them to unite. Now place the live-box under the microscope, and examine the animalcules as closely as you can, and especially so as to ascertain that their stomachs are colourless; then press down the cover until the drops of fluid intermix, which may be done under the microscope, and you will immediately perceive the creatures in great activity, and readily distinguish the cilia and proboscides of those which possess them, while in a few seconds their stomachs will be filled with the coloured substance. Some animalcules, however, take a considerable time to effect this, but such is an exception to the general rule.

SECTION VIII.—*On the Mode of Drying and Preserving Infusoria.*—Although such exceedingly small creatures as animalcules, when dead, lose many of their characteristic features, especially the soft-bodied ones, yet, for the verification of some parts of their structure, such as the mandicatory organs, muscular system, and visual points, it is absolutely necessary to observe them in a quiescent state; and hence, a method of effectually drying and preserving them must be

considered essential. *Bacillaria*, in this condition, have often been preserved by botanists, in collections of minute Algæ, and with very little management; but other families will require more care. Having selected the creature you wish to preserve, remove it with a fine pointed quill, and put it on a slip of glass, or other convenient receptacle. By this means there will be but a small portion of water surrounding it, which may be removed by some pointed pieces of ragged blotting paper. When you have withdrawn as much of the water as possible from the specimen, the remaining moisture may be readily evaporated, by placing the glass on the palm of the hand. The *Hydatinea* may be best preserved when destroyed with strychnia, and then rapidly dried. By what mode soever life may be taken away, it is absolutely expedient that they should be speedily and carefully dried, otherwise their bodies will be decomposed, gases evolved, and the object will fail.

I have seen a fine collection of dried specimens of *Rotatoria*, preserved by Ehrenberg between small discs of mica. These are very portable and may be carried about in a pocket book. Each specimen worthy of observation, had a ring of paper gummed to the mica. The discs of mica were about three-eights of an inch in diameter. Several of these discs were arranged in a row, and attached to a slip of mica three inches long and one-eighth of an inch wide.

Another way of mounting for the microscope dried Infusoria, is on slips of plate glass, having a polished circular cavity, in which to deposit the creatures. These may be numbered, or otherwise marked, with a writing diamond, and a large collection of them arranged in a very compact case.

Fossil Infusoria are best preserved in Canada balsam, under thin slips of glass. (See Section X.)

Infusoria, when simply dried, may be relaxed again by moisture, and some of them will bear this operation several times—the soft-bodied ones, however, only once. The general colour of Infusoria is retained for a considerable time after they have been dried, but the pigment of the eye is soon lost. It may be well to observe, that when the preserved specimens are intended to illustrate the nutritive system, they should be previously fed with colouring matter; but for observation on other organs, this is not advisable.

Section IX.—*On Infusoria contained in Flints and Semi-Opals.*—It is hardly possible to take up and examine a dozen flints without discovering species of Infusoria inclosed within them. These may be best seen under the microscope, when very thin sections are made, like those of fossil woods, teeth, coal, &c.: when these are polished and cemented on glass slides, they form permanent objects. Small splinters of flint, broken off, may be used for investigation by the microscope, but such experiments are attended with very considerable danger to the object-glass of the instrument, by its being brought accidentally into contact with their sharp edges, which oftentimes cut and injure it without your being immediately aware of the fact.

Section X.—*To prepare Fossil Infusoria for the Microscope.*—Among various earths, marls, and chalk, will often be found the siliceous shells of *Bacillaria.* Sometimes the whole mass consists of them; in the latter case it will be sufficient to place upon the slides a little of the powder, add a drop of water, and cover it with a thin plate of glass when your object is ready for the microscope. This, however, will be only a temporary preparation. When required to be permanent, Canada balsam, varnish, or gum, must be substituted for the water. By far the majority of specimens of shells of Infusoria are met with among foreign matters, from which it is necessary to separate them as in the case of Guano, &c.

When the earth can be separated by washing in water, this plan may be adopted. In some cases it requires boiling in nitric acid, which dissolves the foreign matter and allows the shells to be separated. In this way some care is required, otherwise the shells will burst asunder, and you will only obtain fragments. Another objection to the use of acids, is that the shells will attract moisture when required to be mounted dry.

Another method of separating Fossil Infusoria from the earths, is similar to that employed by D'Orbigny in separating the beautiful microscopic shells of the *Foraminifera,* and has been successfully adopted by Professor Bailey of New York, in detecting the shells of *Bacillaria* in sedimentary deposits. It is as follows: Take the sediment or earth in which Infusiora are supposed to exist, and gradually, but completely dry it; then take a glass full of cold water and strew the powder upon the surface of the water, when in a few

minutes the earth and sand will sink to the bottom of the glass, and the shells being filled with air, will float upon the surface, and may be removed by gently introducing a slip of glass under them.

SECTION XI.—*On mounting Infusoria permanently in fluids.*—By far the greater number of Infusoria are entirely destroyed when dried, some, however, of the larger kinds, may be preserved in gum water, which, when dry and indurated, will last a long time, if kept from mildew. Canada balsam will preserve some few, but this latter plan is specially applicable to the loricated class.

In mounting objects in Canada balsam, it is requisite to have it, as also your glass slides, kept warm. The slide, with objects on it, should be held over a small flame, and a drop of the balsam allowed to fall upon it. When this is sufficiently heated, the whole should be covered with a thin plate of glass, and placed in a warm situation until it becomes hard.

As many organisms cannot be preserved in gum or balsam, and alter and change their forms when dry, it becomes essential to their due preservation to mount them (as it is technically termed,) in a fluid. To effect this purpose effectively, two particulars are necessary to be observed—first, the selection of the fluid; and second, the mechanical contrivance for permanently enclosing it with the specimen.

The requisite qualities in a preserving fluid are—first, that its refractive power shall be such that it will permit the outline or boundary of the specimen to be distinctly seen. This cannot be, if its refractive index is the same as the object enclosed. When the object is surrounded by a mucus-like envelope, this consideration is important. Second, that it will not change the colour of the specimen, or decompose any of its delicate parts. In the *Bacillaria*, the green matter, called by botanists *endochrome*, and which is so beautiful a character in the *Desmidieæ*, is soon injured by corrosive fluids. Third, the fluid must not facilitate or permit the growth of minute fungi, or the development of any organic filaments, as the germs or spores of these minute beings are almost everywhere present, and, indeed, it is hopeless to procure specimens free from them.

The first two conditions are best complied with by the use of dis-

tilled water, but the third is fatal to its employment in a pure state, hence various formulæ have been proposed, of which the following are the chief :—1. Brine, that is, a solution of common salt in water. 2. Alum dissolved in water. 3. Corrosive sublimate (bichlorate of mercury) in water. 4. Sulphate of the peroxide of iron dissolved in water. 5. Sulphate of zinc dissolved in water. 6. Sal ammoniac (hydrochlorate of ammonia) in water. One or other of these solutions are recommended by different naturalists, while those who recommend the same, differ, in the degree of concentration necessary. In all cases it is advisable to use distilled water, and to filter the solution through bibious paper.

Aqueous compound solutions are also employed, but these vary greatly. 1. Dr. Goadby used the following as a preserving fluid, and has had great experience: bay salt 4 oz.; alum 2 oz.; corrosive sublimate 4 grains; and boiling water 2 quarts. These are to be well mixed and filtered. 2. Bay salt 3½ lbs.; corrosive sublimate 7 grains; and water 6 quarts. 3. Arsenious acid 2 drachms; bay salt 3 lbs.; and water 6 quarts. 4. Another fluid is composed of alum 3 parts; common salt 1 part, and water 24 parts.

Alcohol, creosote, chromic acid, sugar, and glycerine, have each been employed as preserving fluids. The first two require large additions of water to prevent them from corrugating the specimens. Thus five parts of water is used with one of alcohol. Mr. Thwaite's fluid, which is very excellent, is composed as follows: distilled water 16 parts, rectified spirits of wine 1 part, saturated with a few drops of creosote. To this mixture he adds a little prepared chalk, filters, and adds an equal measure of camphor water.

In some cases Canada balsam mixed with castor oil has been used, while gum water, when slowly dried with the specimens, and afterwards surrounded by a varnish, often answers very well.

The mechanical contrivances for securing the specimens and fluid, are as various as the fluids.

The size of the glass slides should be uniform, the usual length generally adopted, is that given in my little work entitled a List of 2000 Microscopic Objects, namely, three inches: the width will vary to suit the preparations, but one inch is that most usual. Having

procured a number of these glass slides, which may have their edges ground and polished. Procure some thin glass either in slips or discs for covers.

Next provide yourself with suitable cement or thick varnish to connect the two. Some preparers use the painters white lead to form a shallow cell, which holds the specimen with a drop of preservation fluid. Others use "gold size," which they thicken with lamp black, or litherage. When deeper cells are required, but which are rare for Infusoria, thin slices of glass tube, or rings of gutta percha, cemented to the slides with Canada balsam, or varnish are used. In any case the operator will, by the use of his judgment, and a little experience, soon find a method to suit his purpose. It is, therefore, unnecessary to enter into minutiæ. The desirata is a substance which, when indurated, is strong and not brittle, and second, the filling the cell so that no air be left in it.

In all cases where Canada balsam, or any other substance that indurates can be used for preserving objects, cells of fluid should not be employed. That this remark is correct, may be inferred from the very general use of Canada balsam, a substance which I first proposed for that purpose, and gave to the public after many previous trials with gum and varnishes.

For further particulars on this subject, see "Microscopic Cabinet" and "Microscopic Objects."

SECTION XII.—*To mount Infusoria as Opaque Bodies.*—This method of mounting applies principally to the siliceous shells of the *Bacillaria*. It consists of fixing by gum or varnish, to a black disc or cylinder, the specimens to be examined. Where this plan can be adopted, it is always desirable, as it affords a more correct view of the structure of the surface, indeed it is the best verification that can be obtained. In some cases fragments of the earths containing *Naviculæ, Campilodisca,* &c., may be mounted without separation; in other cases, the shells may be separated by solution of the lime and foreign matter, and only the washed shells mounted.

PART III.

CLASSIFICATION AND DESCRIPTION

OF

INFUSORIAL ANIMALCULES.

Class I. POLYGASTRICA.

Note.—The Abbreviations used herein, are explained at the end of the Contents.

This class of animalcules is denominated Polygastric from possessing a digestive apparatus composed of many globular vesicles, which perform the functions of stomachs. They have no perceptible nervous cords or pulsation. They are hermaphrodite, and increase by self-division, or by the growth of gemmules, or of little buds, upon their bodies; hence their external forms appear to vary. Their locomotive organs consist of processes (often vibratory), but they are destitute of true articulated feet.

The Polygastric animalcules, according to Ehrenberg, comprehend the following families, whose relations to each other may be seen in the table on the next page.

Anentera, without true alimentary canal.	Body destitute of appendages. (No foot-like processes). *Gymnica.*	Form of body constant	self-division complete	illoricated or shell-less	Monadina
				loricated or shelled	Cryptomonadina
			self-divison incomplete hence formed in clusters	illoricated	Hydromorina.
				self-dividing on all sides (globular	Volvocina.
				self-dividing unilaterally — illoricated	Vibrionia.
				(filiform) — loricated	Closterina.
		Form of body variable	illoricated		Astasiaea.
			loricated		Dinobryina.
	Foot-like processes variable. *Pseudopoda.*	illoricated			Amoebaea.
		loricated	compound foot-like process from one aperture		Arcellina.
			simple foot-like process from one or from each aperture		Bacillaria.
	Hairy *Epitricha.*	illoricated			Cyclidina.
		loricated			Peridinaea.
Enterodela, with an alimentary canal.	One receiving and discharging orifice only for nutrition. *Anopisthia.*	illoricated			Vorticellina.
		loricated			Ophrydina.
	Two orifices one at each extremity. *Enantiotreta.*	illoricated			Enchelia.
		loricated			Colepina.
	Orifices situated obliquely *Allotreta.*	illoricated	mouth furnished with proboscis, tail absent		Trachelina.
			mouth, anterior, tail present		Ophryocercina.
		loricated			Aspidiscina.
	Orifices abdominal. *Catotreta.*	illoricated	locomotive organs cilia		Kolpodea.
			——— various		Oxytrichina.
		loricated			Euplota.

Family—MONADINA.

The animalcules of the family *Monadina* are the most minute living creatures which have been discovered by man. They are destitute of an alimentary canal; are illoricated or shell-less, and have an uniform body without any appendages issuing from it, cilia not being considered as such. They increase either by a simple and complete self-division of the body into two, four, or more individuals. The uniformity or unvarying appearance in their external forms may be considered as one of the principal characteristics of this family; for

no *Monadina* can voluntarily alter the shape of its body, whether into a filiform, knotty, or globular figure, nor can it extend any portion of it, and then contract it again. It is quite evident that they all possess organs of locomotion, nutrition, and propagation, which latter are of the hermaphrodite character. Some of them have a rudimentary eye, but it has never been discerned that they are furnished with a vascular or circulating system, which, however, is not surprising, when we reflect that should they possess it (a supposition by no means to be rejected), the diameters of the tubes of this system would necessarily be of such extreme minuteness as to defy investigation.

The groups and figures in *Plate* I., numbered I to 20, convey a very fair idea of the appearance of the *Monadina.* None but microscopes of high magnifying powers can develope their structures; indeed, they cannot be observed accurately with a less amplification than 500 diameters, together with considerable penetration and a good definition.

The family is distributed by Ehrenberg among nine genera, as follow;—

- Tail wanting
  - Lips wanting
    - Swimming
      - Eye wanting
        - Single .... Monas.
        - Aggregate .... Uvella.
      - Eye present
        - Single
          - Proboscis one or two .... Microglena.
          - Proboscides not more than four .... Chloraster.
          - Proboscides many .... Phacelomonas.
        - Aggregate .... Glenomorum.
    - Rolling .... Doxococcus.
  - Lips present .... Chilomonas.
- Tail present .... Bodo.

Reference to the classification proposed at (page 62), will show that the genera comprehended by Ehrenberg, in this family *Monadina*, as well as in *Cryptomonadina*, *Volvocina* and *Vibrionia*, are not recognized as Infusoria, by Siebold. For so extensive an exclusion of genera from the list of Infusoria, Siebold offers no distinct and clear explanation, but from his remarks, we may gather that the excluded

organisms are in his opinion of vegetable origin, and more especially embryonic forms, such as spores of various Confervæ, of Vaucheria, &c. That eminent comparative anatomist states, (Anatomie der Wirbellosen Thiere, Book 1st., p. 8. Berlin, 1848), that "ciliated organs occur in the vegetable kingdom, in the form of ciliated epithelium in the spores of Vaucheria, and in the shape of long filiform isolated fibres, in the spores and early stages of existence of several species of Confervæ; many of which organisms indeed, Ehrenberg has described as belonging to the families *Monadina*, *Volvocina*, &c."

The active movements of the *Volvocina* are identified with those of plants, and, to Siebold's mind, distinguished from those of true animal Infusoria, such as the *Kolpoda*, by entirely wanting a voluntary character.

Another distinction, separating such genera from the animal series, the same naturalist finds in the unalterability or fixity of their general outline, all animals having the power of varying their outline, by the contraction or expansion of their substance.

M. Dujardin, although admitting generally the animal nature of the families in question, differs very materially from Ehrenberg, in his views respecting their organization.

The third order in the classification of this naturalist which includes the *Monadina*, *Volvocina*, *Dinobryina*, *Thecamonadina*, *Euglena* and *Peridinia*, has for its common characteristic the existence of one or of several flagelliform filaments, serving as locomotive organs. But, Dujardin's definition of the family of Monads differs widely from that of Professor Ehrenberg, in assigning no mouth or digestive sacs, and in attributing to them a form generally variable, and a capability of contracting adhesions to one another, owing to their soft gelatinous bodies being unprotected by any epidermis. Dujardin, moreover, cannot admit the red specks to be eyes.

The apparent sacs he terms *vacuoles* (vacuolæ), and considers them to be spontaneously hollowed out in the body of the animal, and when, as usual, near the surface, to open externally, and on again contracting, to enclose any foreign particles which may have introduced themselves. According to the French micrographer, therefore, the *Monadina* are nourished only by absorption, effected by their external surface, and, in some measure, by the spontaneously formed vacuolæ.

Dujardin also states that he has been unable to recognize all the genera of Ehrenberg, and believes that the *Microglena, Phacelomonas, Glenomorum and Doxococcus* appertain to another family, that the distinction between the genera *Polytoma* and *Uvella*, is erroneously deduced from the supposed fission of *Polytoma* in two opposite directions, and the periodical grouping of *Uvella*. He thus reduces the genera of Ehrenberg, to four in number, viz *Monas, Uvella, Chilomonas* and *Bodo,* the last comprehending in part his *Hexamita, Amphimonas,* and *Cercomonas*. The subjoined table represents the distribution by Dujardin, of the

MONADINA.

Isolated	A Single Flagelliform Filament.	Proceeding from the anterior extremity.	Moveable in its entire length	Monas.
			Thickened, and moveable only towards the extremity	Cyclidium.
		Proceeding obliquely from behind an anterior prolongation		Chilomonas.
	Several Filaments.	A second filament or lateral appendage.		Amphimonas.
		A second filament, or posterior appendage.		Cercomonas.
		Two equal filaments, terminating the rounded angles of the anterior extremity.		Trepomonas.
		Four equal filaments in front, two thicker behind.		Hexamita.
		A second filament proceeding from the same point as the flagelliform filament, but thicker trailing and retractile.		Heteromita.
	A filament and vibratile cilia.			Trichomonas.
Aggregate	Groups always free and whirling.			Uvella.
	Groups fixed to the extremity of a branching polypdom			Anthophya.

As to the mode of propagation of the *Monadina,* Dujardin states that he has never witnessed the spontaneous fission described by Ehrenberg, but thinks it more probable that their multiplication takes place by the separation of a lobe, or of the termination of an expansion.

We may gather, from the following summing up given by Dugardin, after his general indications of the genera of *Monadina,* what value he assigns, in the present state of knowledge, to any attempted classification of such minute creatures. He remarks, "But these generic distinctions are entirely artificial, and simply intended to facilitate the naming of Infusoria one may have met with, in such and such an infusion, and which better known, may prove in some instances but varieties of a single species." (Hist. Infus. p. 273.)

A recent paper, published by M. Agassiz, makes us acquainted with the views of that eminent naturalist on the *questio vexata* of the relations of the Infusoria to other organized beings. He observes, "Recent investigations upon the so-called *Anentera* have satisfactorily shewn, in my opinion, and in that of most competent observers, that this type of Ehrenberg's *Polygastrica* without gastric cavities, and without alimentary tube, are really plants belonging to the order of Algæ in the widest extension of this group, while most of the *Monas* tribe are merely moveable germs of various kinds of other Algæ." (Ann. Nat. Hist. 1850. p. 156.)

The above views opposed to the animal nature of the *Monadina* are given *in extenso*, but the candid observer will find, if he examines these organisms, that the balance is in favour of their being animal. The extreme minuteness of these animalcules renders it difficult for the mind to comprehend them or compare them with large animals, but difference of magnitude, however great, is no actual bar to vital power, while the cilia of the animalcule connects man himself with it, the first moving instrument in the human embryo being a cilium, which is retained to the end of life.

Genus Monas.—*The Monads.*—The animalcules of this genus—the true Monads—are described (see Table) as being deficient of the eye, projecting lip and tail, and always swimming in the direction of the longitudinal axis of the body, their mouth being situated at the anterior part. It is another distinguishing character of the true Monad that it is never seen to cluster with others of its genus, so as to form a berry-like mass, and hence it is designated single, in contradistinction to aggregate. At present, there are twenty-six species of this genus known—two green, two yellowish, three inclining to red, and the remainder colourless; but it should be mentioned, that although there be colour, it must not be regarded as a characteristic to be entirely relied upon. Monads may often be present in water, under inspection, without being seen, through the want of a competent magnifying power. They will be sought for in vain with a power of less than 300 diameters, and even this, in some cases, will be found insufficient. They are besides, as a genus, difficult to be accurately determined, not only on account of their exceeding minuteness, but because the young of animalcules of

other genera are so likely to be mistaken for them; for instance, the young of the *Bacterium, Vibrio, Uvella, Polytoma, Pandorina, Gonium,* &c., when they have separated from their clusters, or issued from their common envelopes. And this difficulty in discriminating them will be more likely to happen when they are not observed, whilst undergoing the process of self-division, or when seen in water containing but a small number of them; in which cases, however anxious we may be to ascertain their name, we must often rest contented with an approximation to the truth. When the water swarms with the creatures, the decision will be far easier, and more to be relied upon, as the characters are then more easily discoverable from the numerous vital relationships presented to us. The observer may, however, be guided to a certain extent by the following rule:—Suppose that in a drop of water containing species of the genus *Vibrio, Bacterium, Uvella,* or *Polytoma* (easily distinguished by their clustering forms), separate Monad-like bodies were to be observed; the probability is that they would be either single forms, or the young of these clustering animalcules, and if there were no great difference in the size of the separate individuals and those forming the clusters, this conclusion would be generally correct; and this rule applies equally to those green Monad-like creatures found amongst *Pandorina* and *Gonia.* The young of the *Chlamidomonas pulvisculus* is very deceptive, and may often be mistaken for an illoricated and eye-less green Monad.

The only locomotive organ which has been discovered in the Monad genus is the single filiform proboscis issuing from near the mouth. The numerous cilia sometimes apparent thereabouts are nothing more than this proboscis in a state of vibratory or rotatory motion. This organ, Ehrenberg observes, has a twofold office to perform, the one being locomotive, and the other to provide the creature with food; hence I have called it a purveying organ.

The nutritive apparatus is readily seen in some of the species in its natural state (instance the *M. guttula* and *M. vivipara*), without the aid of coloured food; in others (*M. termo, M. guttula* and *M. socialis*), it may be demonstrated by the latter means. It consists of several distinct or separate cells (from eight to twenty) which are not all filled at the same time, and which are, for the most part,

invisible when empty, but when distended with a limpid fluid, appear like so many lucid vesicles within the creatures.

The propagative apparatus has been particularly noticed in the species *M. guttula* and *M. vivipara*. It consists of a vast number of granules formed into a net-like mass, and dispersed generally throughout the creature, and of a comparatively large spherical glandular body, which separates by the process of self-division.

Monads propagate also by another method, namely, by a self-division of the creature, either transversely, as with the *Monas guttula*, *M. hyalina*, *M. gliscens*, *M. Okenii*, and *M. socialis*; or longitudinally, as with the *M. punctum* (see fig. 2); both methods have been observed in *M. vivipara*. The formation of gemmules has not been perceived in this genus.

Ehrenberg supposes that they are endowed with the faculty of sensation, and that this is shewn by the alternate vibration and quiescence of the proboscis, when the creature is in a place abundantly supplied with food. In some of the species an eye-like organ has been discerned, but as the species of each genus should be reduced to the rule of a special organ, characterizing a particular genus, these are not considered as true Monads, but form distinct genera, as *Microglena*, &c.

As the Infusoria of this genus are chiefly curious on account of their extreme minuteness, and in no other respect, the species are not deemed of sufficient interest to be expatiated upon at any great length; only their leading characters and size, are therefore given. And we may remark, generally, that most of them are inhabitants of water in which organic matter is undergoing decomposition.

The Monads are arranged under two divisions, according to their external forms. The first division contains all those of a globular or oval shape (globular Monads); second those of a lengthened form, more than twice as long as broad (elongated Monads).

A.—Globular Monads.

(*a*). *True Globular or Sphero-Monads—colourless or whitish.*

Monas *crepusculum*—*The twilight Monad.*—The animalcules of this species are the smallest of all living creatures. They are of a spheroidal form and hyaline, although, when seen in masses, with the naked eye,

they appear of a whitish hue. They are active, and feed on animal as well as fungoid substances. They are found in water wherein animal matter is held in solution, but as the decomposition of the animal matter proceeds, the animalcules die, and their bodies may be seen rising to the surface of the water, and forming a thick and colourless gelatinous stratum. *Group* 1, in the engraving is magnified 800 diameters. They rarely attain to 1-12,00th of an inch in diameter, and never exceed it.

MONAS *termo* (M). *The end or limit Monad,* so named from its having been supposed to be the limit of animal organization. Active, herbivorous, found in stagnant water, and increases rapidly where there is an abundance of vegetable matter undergoing decomposition. Size 1-6000th, although some are not one half or even a third of that measurement.

M. *guttula* (M). *The drop Monad.*—Inactive. May be preserved by drying. Twelve stomach-cells may be seen by the aid of indigo or carmine. Surface appears granulated. Found in vessels of water containing plants or flowers. Size 1-2300th, or less.

M. *vivipara. The viviparous Monad.*—Inactive. Found in stagnant water (**), coloured. Size, 1-620th, or less.

M. *grandis.*—*The great Monad* is of a greenish colour except near the mouth. Proboscis short, 1-3rd or 1-4th the length of the body. It is sluggish. Found in marsh water, very rare. Size 1-430th.

M. *bicolor. The Two-coloured Monad.*—Colourless, excepting one or two green spots within it; attenuated anteriorly. Motion vacillating. Size 1-1440th.

M. *ochracea. The ochre-coloured Monas.*—Yellow-ochre colour. Found in water-courses. Size 1-6000th at most.

M. *erubescens. The pale-red Monad.*—Rose-coloured, and with a slow but continual motion. Found in salt water. Size 1-1728th.

M. *vinosa. The wine Monad.*—Colour of red wine. Tremulous motion. Rejects coloured food. Found in vegetable infusions. Size from 1-12,000th to 1-6000th.

(*b*). *Oval or Egg-shaped Monads—all colourless.*

M. *kolpoda.*—Vacillating motion. Discovered in water in the silver mines of Siberia. Size 1-7200th.

MONAS *enchelys. The flask-shaped Monad.* — Continuous slow motion. Found in marsh water. Size 1-1200th to 1-960th.

M. *umbra. The shadow Monad.*—Rapid motion. Found among fresh confervæ. Size 1-2400th.

M. *hyalina. The diaphanous Monad.*—Active, and seems to leap or jump. Found in stale water in glass vessels. Size 1-6000th to 1-2880th.

M. *gliscens. The gliding Monad*—Gliding motion. Found in watery infusions of the stinging nettle. Size 1-4500th.

M. *ovalis. The little Egg-shaped Monad.*—Tremulous motion. Found in water of the *Anodonta Mollusca.* Size 1-9600th.

M. *mica. The glittering Monad.*—Rotatory and vacillating motion. Inhabits clear fresh water. Size 1-1440th to 1-1200th.

M. *punctum. The point egg-shaped Monad.*—Revolves on the longitudinal axis of its body. (See engraving, *group* 2; the lower figure exhibits one undergoing longitudinal division.) Found in water with tannin. Size 1-1150th.

B.—ELONGATED MONADS.—(*a*). *True Elongated Monads.*

M. *cylindrica. The cylinder-shaped Monad.*—Solitary, colourless, revolves as it progresses. Found in salt water. Size 1-1150th.

M. *Okenii. Okens elongated Monad.*—Red, revolving, vibratory motion, social. Found in running water. Size 1-2300th.

(*b*). *Conical.*

M. *deses. The lazy Monad.*—Green, solitary. Found in water from hills. Size 1-1200th.

M. *socialis. The social Monad.* Colourless, social. Found in water-butts. Size 1-700th.

(*c*). *Top-shaped.*

M. *flavicans. The yellow Monad.*—Social, gliding motion. Found in ditch-water. Size 1-1720th.

(*d*). *Spindle-shaped* (*), *colourless.*

M. *simplex. The simple spindle Monad.*—Gliding and rotary motion. Found in water of the Nile, and at Berlin. Size 1-1720th.

M. *inanis. The empty spindle Monad.* Vacillating motion. Found in stagnant and foul water. Size 1-3600th.

MONAS *scintillans*. *The sparkling spindle Monad.*—Very active. Vacillating motion. Found amongst fresh water confervæ, &c. Size 1-6000th to 1-4600th.

M. *Dumalii.*—Of a deep red colour: they occur in vast numbers in the saltmarsh-water of the Mediterranean, to which they give a deep blood colour. Discovered by M. Joly.

M. *prodigiosa.*—A very minute red Monad, so named by Ehrenberg, from its surprisingly rapid development. It is this animalcule which has produced the blood-like spots occasionally appearing mysteriously on bread and other farinaceous substances, and which have ever been a cause of terror to the superstitious.

Being desirous of making this manual as complete as possible, the following species, described by M. Dujardin, are inserted; but it may be that some of them refer to monads already characterized, but differently named.

M. *lens.*—Figure rounded or discoid; surface in appearance tubercular. Size 1-5200th to 3-5200th. This species, one of the most frequent in animal or vegetable infusions, has been recognised by most of the ancient micrographers. It sends out obliquely a flagelliform filament, three, four, or even five times as long as the body, and mobile in all its length.

M. *concava.*—Body circular, concave on one side, thin in the centre, margin tumid. Filament long, moveable throughout. Found in marsh water, Toulouse, 1-2080th.

M. *globulosus.*—Body globular; form mostly constant; compressed at origin of filament; more globular than M. *lens*, and its surface smooth. Found in sea water at Cette, France. Size 1-2000th.

M. *elongata.*—Body elongate; nodular, flexible, of variable form. Length 1-1200th. Found in marsh water.

M. *attenuata.*—Body ovoid, tapering at each extremity, nodular, vaculæ large and distinct, as is also its filament. Size 1-1660th.

M. *oblonga.*—Body ovoid, oblong, unequal, tubercular, hollowed by vacuolæ. Size 1-3600th. Found in vegetable infusions.

M. *nodosa.*—Body oblong, irregular, nodose, tapering behind, truncate in front, filament arising from centre of truncate extremity. Size 1-2170th. Found in sea water at Cette, France.

M. *gibbosa.*—Body oblong, angular, irregularly distended and

gibbose, filament springing mostly from an anterior constriction. Length 1-2000th. Found in infusions of gelatine.

MONAS *varians.*—Body oblong, narrower in front, very soft, and variable in form. Length 1-650th to 1-700th.

M. *intestinalis.*—Body very elongated, form constantly changing, or one end rounded, the other tapering, to terminate in a long filament, motion undulatory. Length 1-1600th. Found in the excrement of a newt (*Triton palmipes*). "I think this is one of the species of *Bodo*, described by Ehrenberg as met with in the intestines of frogs." (Duj.)

M. *fluida.*—Body soft, semi-fluid, form variable, irregularly ovoid, sometimes constricted posteriorly, hollowed by large vacuolœ. Size 1-2600th.

M. *constricta.*—Body elongated, four or five times longer than broad; constricted, often much so at the centre. Length 1-1300th.

Genus UVELLA. *The grape Monads.*—The species of this genus are very well characterised by their aggregating together occasionally, so as to form a grape or mulberry-like mass, and by their generally possessing two (?) hair-like proboscides at the mouth. Like the beings forming the genus *Monas*, they are deficient of the projecting lips, visual organ, and tail, and have the mouth situated at the anterior extremity. They progress also in the direction of the longest axis of their body, and are capable of complete self-division. There are six species—two green, and the remainder colourless.

This genus belongs to the aggregate *Monadina* of Dujardin, and is thus defined by him, "animals globular or ovoid, having a single flagelliform filament, and living aggregated in spherical masses, freely moving about in the liquid." He further observes that isolated individuals are not at all distinguishable from simple Monads, that there is no good reason to suppose the *Uvella* to live alternately isolated, and in masses, and hence that the absence of this circumstance cannot be employed to separate them from *Polytoma,* or its existence to characterize the latter.

Dujardin describes only two species, viz., *U. virescens,* and *U. rosacea*= *U. glaucoma.* (Ehr.)

U. *virescens.* (*Volvox uva,* M.)—Body ovate, and of the colour that gives rise to its specific name. Found in serrated groups

amongst confervæ and lemna. Size 1-2000th; diameter of cluster 1-280th.

UVELLA *chamaemorum.*—Smaller than the preceding one. Found in water-butts. Size 1-2880th; diameter of cluster 1-570th.

U. *uva.*—Has indistinct vesicles, and is very small. Found in stagnant water. Size 1-4800th; diameter of cluster 1-960th.

U. *atomus.* (*Monas atomus, M. lens et Volvox socialis,* M.)—Voracious, with large vesicles. Size 1-6900th to 1-3406th; diameter of cluster 1-1150th.

U. *glaucoma.* (*Volvox socialis,* M.)—Form oval, but inclining to conical, with the posterior extremity attenuated as it advances in age. Hyaline, with large vesicles, and two evident filiform proboscides: individuals loosely aggregated. In 1831, Ehrenberg first observed a vibration at its anterior part, and its reception of coloured food. In 1835, he discovered within the body of this minute creature some green Monads which it had eaten, and by which it was proved to subsist by prey. When fed on indigo, as many as twelve stomachs were filled, and it has been sometimes seen to void little blue particles, like undigested matter, from its mouth. With a power of 800 diameters, a great number of small colourless granules, having the appearance and form of ova, may be discerned lying between the nutritive sacs. It increases both by transverse and by longitudinal fission. Engraving, group 3, represents a cluster of these creatures; figures 4 and 5, separate young ones; and 6, an old one. They are magnified about 350 diameters. The individuals, when full grown, are elongated. Found in water-butts. Size 1-2300th to 1-2350th; diameter of cluster 1-430th.

U. *bodo.*—Fore part of the body rounded; posterior attenuated. It is of a beautiful green colour; found in stagnant water. Size 1-4030th to 1-3450th; diameter of cluster 1-2350th.

Genus MICROGLENA.—*The eye Monads.*—This genus is essentially characterized by all its species having a minute red eye-like speck situated at the anterior part of the body. In other respects they resemble true Monads, being deficient of the projecting lips and tail, and swimming in the direction of the long axis of the body. They possess a very delicate flagelliform proboscis, of simple structure.

They multiply by a complete self-division of the body. Two species only are known, the one yellow, and the other green.

We now approach the description of living creatures, whose organization, on account of their magnitude, is rendered more apparent to us. The red eye-like speck, the distinguishing feature of this genus, Ehrenberg assumed to be a rudimentary visual organ, although nervous ganglia subservient to it have not been perceived, as in the still larger Infusiora, the *Rotatoria*, and in the single-eyed genus of Entomostraceans, the *Daphnia*. This organ, together with the proboscis,—its locomotive and purveying instrument, the beautiful green homogenous granules (seen in *M. monadina*, which, by their shape and situation in the body, leave no reasonable doubt of their being ova,) and the grey rolled band-like seminal gland, demonstrate that these living atoms are endowed with an organization (a sensitive one two) as comfortable to their particular uses, and as well adapted to supply the wants of the creatures, as those even in the largest fish. Still are we left to conjecture with respect to their possessing a vascular system or not; it has never been perceived, and we can only argue, as we have done already, that if there be one, the vessels in being so minute must necessarily be of such delicate structure, that we may not as yet have found out the means of making ourselves acquainted with them.

Microglena *punctifera* (*Enchelys punctifera* M.)—Colour yellowish, form oval, or almost conical; terminated acutely at the posterior extremity. Eye, red with a blackish central spot, as if a secondary visual appendage. Found among slimy water plants. Size 1-620th.

M. *monadina*. — Beautiful green-colour; form ovate, rounded equally at both extremities; a distinct single red eye, proboscis nearly as long as its body; motion vibrating, rotatory on its long axis. *Figures* 12, 13, and 14, represent three animalcules magnified, the first 800 diameters, exhibiting all the internal organization noted above. Found among slimy water-plants (Hampstead and Finchley). Size 1-2300th to 1-720th.

Genus Chloraster.—Solitary, without tail: mouth terminal: with a frontal ocellus, central portion of body with radiating rows of raised points *(veruccæ.)* It is allied to the genera *Glenomorum.*

and *Phacelomonas;* but differs from the former in being solitary—not clustering, and by the greater number of proboscides; whilst the last are fewer than in *Phacelomonas.* This is a new genus established by Ehrenberg.

CHLORASTER *gyrans.*—Green; central part of body fusiform; both extremities acute; central rays in a whorl of four. Proboscides 4-5. Size 1632-a.

Genus PHACELOMONAS. *The fan Monads.*—The distinguishing characters of this genus are the numerous proboscides placed round the mouth of the creature, forming as it were a wreath of cilia, and from 8 to 10 in number. In other respects it resembles *Microglena:* it has the small red eye, the truncated mouth at the anterior extremity, and is deficient of the tail. It swims in the direction of the longitudinal axis, and its self-division is simple and complete, but not constant in occurrence. Many stomach-cells have been observed within the body, but they have not been seen to admit coloured food. This genus has not been illustrated by Ehrenberg.

M. *pulvisculus* (*Monas pulvisculus,* M.)—Form oblong or slightly conical, attenuated posteriorly, and of a beautiful green colour. Just previous to self division, its body becomes cylindrical, then contracts at the centre; but when dying it changes to a globular shape. In swimming, it turns quickly upon its longitudinal axis, without any vibration. This animalcule demonstrates the fact, that proboscides and cilia are organs not materially different from each other. Found in green puddles. Size 1-1152nd.

Genus GLENOMORUM. *The bride Monads.*—This genus is especially indicated by its possessing a single red eye, a truncated mouth, and double filiform proboscis; by its being destitute of a tail, by the individuals moving on the long axis of the body, by their self-dividing simply and completely into two, or not dividing at all; and by their *voluntarily* clustering, as occasion may require, so as to give themselves the resemblance of a bunch of grapes.

In this enumeration of the characters bolonging to this genus, we are presented with an excellent illustration of the table (and one that exceedingly well explains its use), under which all the genera of the family *Monadina* are arranged, so as to exemplify in what respects they are alike, and in what they differ from each other. (For ex-

ample, see Table, p. 117.) The *Glenomorum* closely resembles the *Uvella*, but differs from that genus by the superaddition of the red eye; it differs from *Monas* and *Microglena* in occasionally aggregating from *Chilomonas*, in being deficient of the projecting lips; from *Bodo*, in not having the tail; from *Phacelomonas*, by the double proboscis; from *Doxococcus*, by swimming, instead of rolling over or revolving in the water; and from *Polytoma*, by never appearing in clusters whilst undergoing self-division.

Glenemorum *tingens.*—Body fusiform, of a beautiful green colour, and three or four times longer than it is broad. Its double proboscis is exceedingly delicate, and about half the length of its body; within it may be seen some small whitish vesicles, the stomach-cells, and also some minute granules, which give rise to the green colour, and may be considered ova. About the centre of the body is a large transparent colourless organ, which Ehrenberg supposes to be of a male sexual nature. The beautiful red eye is fixed internally, about one-third from the anterior extremity of the body. These animalcules constitute a great portion of the green matter commonly seen on stagnant water, and discovered by Priestley. They appear to be nearly allied to *Cercaria viridis*, differing from this only in magnitude, and in the unalterable form of their bodies. Figure 15 represents two clusters; 16, single ones, magnified 250 times; 17, another magnified about 450 diameters. Found plentiful at Hampstead. Size 1-3600th to 1-1700th.

Genus Doxococcus. *The revolving Monads.*—The individuals of this genus differ from those of the whole family *Monadina* by the singularity of their motion, which may be defined to be neither that of swimming nor of rotation, but a sort of rolling over and over. In other particulars they are like the Monads. They have the same unvarying form, and are destitute of the eye, projecting lips, and tail. Their self-division is simple and complete, or they do not divide at all, in which case they increase by ova. These characters are sufficient to distinguish them from all other Infusoria, and to justify their being placed in the family *Monadina*. Four species are known.

D. *globulus (Volvox globulus*, M.*)* Form subglobose or ovate; transparent as water; easily known by its tedious rolling motion; mouth not discerned. Found in salt water. Size 1-860th.

DOXOCOCCUS *ruber*.—Form globular; coloured brick red, opaque. Ehrenberg appears to doubt whether this animalcule holds its proper situation here, or whether it should be placed with the genus *Trachelomonas*, though its motion is very peculiar; and he has not been able to satisfy himself of the existence of a lorica, or shell, enveloping the creature. Group 18 represents three magnified individuals. Found amongst confervæ, &c. Size 1-1720th.

D. *pulvisculus*.—Form perfectly (?) globular; colour green, but opaque. Found amongst confervæ. Size not exceeding 1-1280th.

D. *inequalis*. Form irregularly globular; transparent, and covered with green spots. Found amongst confervæ. Size 1-2400th.

Genus CHILOMONAS. *The lip-monads* constitute but a small genus. They are characterized by the oblique position of the mouth, with respect to the longitudinal axis of their bodies, which occasions an overhanging or projecting form above the mouth, of a lip-like appearance. All the species propel themselves in the direction of the long axis of the body. Their form is invariable, and they are devoid both of the eye and tail. Whether the projecting lip is furnished with cilia, or with a double flagelliform proboscis, Ehrenberg has not satisfactorily determined. He states, however, that two proboscides are to be distinctly seen on the C. *paramecium*, whilst on the C. *destruens* there is a number of cilia, which are not quite so apparent. Their self-division is either simple and complete, or they do not divide.

Dujardin's characters of this genus are, "Animal with an ovoid oblong body, obliquely notched in front, with a very slender filament proceeding from the bottom of the notch. Movement from before, backwards on its centre. It is with doubt that I refer the Infusoria I thus name to the genus *Chilomonas* of Ehrenberg. The mode of insertion of the filament behind a projecting lip-like portion, approaches the animals to the *Euglena* and to certain *Thecamonadina*, but I cannot discover any trace of an integument, either contractile or resistant."

C. volvox.—Form ovate; attenuated and truncated anteriorly; transparent and colourless; projecting lip long; they will feed on indigo. Found in stagnant water. Size 1-1440th.

C. *paramecium*.—Form oblong, keeled longitudinally, colour re-

sembling dirty water. This animalcule is easily distinguished by its shape and peculiar lip-like process. With a power of about 240, numerous digestive cells are visible; and with 380, the two proboscides, which are half the length of the body, may be perceived. It moves in the direction of its long axis, but in a fluctuating or wavering manner. It sometimes clusters. Group 19 represents two of these creatures magnified 380 times, and six others less magnified. Three are clustered. Found in water wherein wheaten bread has been steeped. Size 1-1020th.

CHILOMONAS *destruens.*—Form oblong, but variable, on account of its softness. Faint yellow, nearly colourless. Found in salt and fresh water, and in the bodies of dead *Rotatoria*, for instance, *Anuræa foliacea*, and *Monocerca rattus.* Size 1-860th.

C. *granulosa* (Duj.)—Body colourless, oblong, larger anteriorly than posteriorly, of almost invariable form, although of gelatinous consistence, filled with granules which seem to project from its surface. Filament flagelliform, very fine, arising from an oblique notch. Length 1-940th to 1-850th.

C. *obliqua.*—Body ovoid, or pyriform, nodular of variable form, with its filament arising laterally. Length 1-2600th.

Genus BODO. *The tailed Monads.* The caudal appendage at the posterior extremity of these animalcules is a decisive character of the genus. In other respects, the species may be described as being eyeless, and having the terminal mouth furnished with a single (?) filiform proboscis, and as undergoing self-division, simply and completely into two, or not dividing at all. These creatures never constitute true or perfect clusters, like some of the family *Monadina*, although, like the *Uvella*, they occasionally enter into social compact. In *B. grandis*, several digestive sacs have been observed, and (as also in the *B. intestinalis*) a simple (perhaps double?) proboscis. The *B. didymus* has been known to divide transversely. Only one of the species of this genus having fallen under my own investigation, the account of them here given is entirely abstracted from *Die Infusionsthierchen.*

This genus *Bodo* partly comprehends the genera *Hexamita*, *Amphimonas*, and *Cercomonas*, of Dujardin, which are with others introduced as addenda to this family *Monadina.*

Bodo *intestinalis.*—Form almost conical, tail of equal length with the body, transparent and colourless. Found in several living animals, such as frogs, toads, &c. In the grey and edible frogs, amongst the watery mucus of the alimentary canal, Ehrenberg has observed great numbers of these creatures, and remarks that the *Cercaria gyrinus* of Müller (a different animalcule) might pass as a representation of this species, and that it was confounded by its discoverer with the spermatic animalcules. Group 20 represents them magnified about 300 diameters. Size 1-1720th.

B. *ranarum.*—Body turgid, ventricles indistinct. Found in live frogs, with the preceding species, and with the *Bursaria ranarum.* Size 1-1440th.

B. *viridis.*—Form nearly globular, tail very short, colour green. Found amongst confervæ. Size 1-2400th.

B. *socialis.* (*Monas lens,* M.)—Form ovate or subglobose; tail often longer than the body; transparent and colourless. Clusters into a mulberry shape. Single forms are sometimes observed hopping. Common in stagnant water. Size 1-2970th.

B. *vorticellaris.* *The bell-shaped Bodo.*—Body three times as long as it is broad; tail very short. Found in fresh water. Size 1-11200th.

B. *didymus.* *The double-tailed Bodo.*—Body generally constricted about midway, tail short. Size 1-9600th.

B. *saltans.*—Very small; body with ample ventricles; tail short. This creature, most probably from its small size, has been mistaken for Müller's *Monas termo,* but its brisk leaping movement will sufficiently distinguish it. Size 1-1200th.

B. *grandis.*—Form oblong, vesicles ample, tail rigid setaceous, affixed to the abdomen. Found in stagnant water. Size 1-864th.

B. *oystea.*—Body globular; the anterior three-fourths occupied with vesicles, the rest hyaline; length of tail four times the diameter of body. This active creature I discovered in the liquor of an oyster, swimming freely among the ova (Sept. 1834.) Diameter 1-2000th.

The following genera named and described by Dujardin, are introduced into his family *Monadina.*

Genus Cyclidium, (D.)—Body discoid, compressed, or lamelliform,

scarcely variable, with a filament, having a thicker and more flexible base, than that of *Monas*, the free extremity only being moved.

This genus is as yet but artificial, and provisional indeed, true monads perfectly developed, may possess a filament, with a thicker base; and again, the constant outline of the body, may be the consequence of the presence of an integument, in which case the animalcules in question would be referable to the family *Thecamonadina.* Movement slow and uniform.

It is to be regretted, that Dujardin uses this generic name, as Ehrenberg previously employed it to designate certain ciliated animalcules, which correspond but partially with those of Dujardin, under this title. To render this work complete, they are introduced, and, we hope the reader will not be confused. Dujardin observes, that "the genus *Cyclydium* (Ehr.), contains monads also, and very probably some of those to which I have applied the same 'generic' name."

Cyclidium *nodulosum.* (Duj.)—Body flattened, discoid, with rows of nodules and vacuolæ, movement extremely slow, Length 1-5200th. Found in water from the Seine.

C. *abscissum.* (Duj.)—Body membranous, lamelliform, truncated posteriorly, filament rigid, movement slow, regular. (P. 21. f. 15.) Length 1-1040th.

C. *crassum.* (Duj.)—Body oval, thick and rounded, filament thickened at its base, and rather sinerous; movements more active, zigzag. Length 1-1090th. Length of filament 1-600th.

C. *distortrum.* (Duj.)—Body oval, flat, nodular, irregularly bent with a tumid border. Length 1-1800th to 1-800th. (P. 21. f. 14.)

"This species is perhaps but one phase of development of *Monas lens*, it was found in Seine water, kept during three months. When young it has the form of a disc, with a tumid and nodular margin; when, however, it has grown larger, it becomes twisted upon itself, and its movement irregular. Some individuals offered a certain affinity with the Trepomonads, which favours the opinion already advanced, that the majority of the *Monadina*, are but modifications of one or of several types."

Genus Cercomonas, (D.)—Body rounded or discoid, tubercular,

with a posterior variable process in the form of a tail, of greater or less length and fineness.

The Cercomonads differ from the Monads in the posterior prolongation, serving by the adhesion of its extremity as a point of support, and which is either elongated as a very fine thread, or contracted into a small tubercle. It is sometimes nearly as fine at the anterior filament, and susceptible of an undulatory motion. I have not unfrequently witnessed the transition of monads to the condition of Cercomonads.

We may conclude that many of the animalcules described in the genus *Bodo*, (Ehr.), are examples of this genus *Cercomonas*, Duj., although sufficiently marked characters are wanting, in order to discover special identity.

CYCLIDIUM *detracta.*—Body discoid, or oblong, granular, with a thick tail. Length 1-7000th., 1-2300th.

C. *crassicauda.*—Body elongated, nodular, flexible or variable form, more or less contracted posteriorly into a tail. Length 1-3400th, 1-2600th.

C. *viridis.*—Body ovoid, oblong, tubercular, green, prolonged posteriorly into a tail of varying tenuity, or into a rounded lobe, or spatulate expansion. Length 1-1500th.

C. *lacryma.*—Body globular, unequal, elongated posteriorly, as a long, flexuose tail. Length of body 1-5200th., 1-3000th. Length of tail 1-2600th. Length of filament 1-750th.

C. *accuminata.*—Body globular or ovoid, contracted posteriorly into a short tail, terminating by a very fine filament. Length 1-2600th., 1-1900th.

C. *globulosus.*—Body globular, with a filament at each extremity double its length, the anterior one, more actively moved. Length 1-2600th. Found in marsh water.

C. *longicauda.*—Body fusiform, flexible, terminated posteriorly by a long and very slender filament, also flexuose. Length of tail 1-1800th.

C. *fusiformis.*—Body dilated at centre, constricted in front, and prolonged behind into a long delicate tail. Length of body 1-1900th.

C. *cylindricus*—Body cylindrical, elongated constricted posteriorly,

terminated by a long straight, and very thin tail. Length of body 1-2600. Length of tail the same.

Cyclidium *truncata.*—Body contracted posteriorly, truncate in front, and having a filament springing from each of the truncated angles, the other angle being extended more or less into a lobe. Length 1-3000th, 1-1900th.

C. *lobata.* Body variable in form, tubercular, sending out a flagelliform filament from the end of an anterior lobe, and emitting also one or two other lobes. Length 1-3250, 2-3250.

Before proceeding with the next genus it is right to mention that Dujardin has noted the occurrence of several of the above Cercomonads, in organic infusions in conjunction, particularly with *Monas lens,* and that he inclines to the idea of these differently named Infusoria, being but different conditions of the same animalcule.

Genus Amphimonas. (Duj.)—Animal of variable irregular form, having at least two filaments, of which one is either in front, and the other on one side, arising from a constriction of the body, or both are lateral, and accompanied or not with a caudiform prolongation. The leaping movements of these creatures offer a good character.

A. *dispar.* Body oblong, of very variable form, one or other of its ends constricted, or prolonged laterally into two filaments, or exhibiting them approximated at the anterior extremity. Length 1-3500th to 1-2900th. Movement active, jerking.

A. *caudata.*—Body of very variable form, mostly depressed, tubercular, convex on one side, angular on the other, with a filament proceeding from the summit of each angle. Length 1-2180th to 1-1300th.

"This species seems to me (says Dujardin) to be allied to the *Bodo saltans* of Ehrenberg. In every example I saw two flagelliform filaments, one from the anterior, the other from the lateral angle ; a caudiform prolongation obtuse, or drawn out as a third filament, often adhered to the slide."

A. *brachiata.*—Under this name is indicated an animalcule of the family *Monadina,* which Dujardin only once met with, of an ovoid or pyriform shape, filled with granules, and giving off from its narrower anterior end, a simple flexuous filament, together with a variable dilated lobe, emitting two other filaments having an undu-

latory motion. The animal progressed by leaps, revolving at the same time.

Genus Trepomonas, (D.)—Animals with a compressed body, thicker and more rounded posteriorly; with two anterior curved narrow lobes, each terminated by a flagelliform filament, producing an active whirling and jerking movement.

The examples of this genus are very common in all collections of marsh water containing decomposing plants, but are most difficult to determine, owing to the irregularity of their form and the rapidity of their movements. I have rather glimpsed than certainly detected their flagelliform filaments, and have in vain attempted accurately to delineate them.

T. *agilis.*—Body granular, unequal. Length, 1-1300th.

Genus Hexamita, (D.)—Animals with an oblong body rounded in front; constricted and bifid or notched behind. Two to four filaments extend from the anterior border, and the two posterior lobes are prolonged as two flexuous filaments.

This genus, characterized by the number of its motor filaments, appears sufficiently distinct from the preceding. Its species occur in decomposing marsh water, or in the intestine of Batrachians; but not in artificial infusions.

H. *nodulosa.*—Body oblong, with three or four longitudinal rows of nodules, the two lateral of which are extended into tapering slender lobes, each terminated by a filament. Movement vacillating. Length 1-1300th to 1-1500th. (P. 21. f. 1.)

H. *inflata.*—Body oval oblong, rendered almost quadrangular by the processes, giving origin to the filaments. Length 1-600th—1-1300th.

H. *intestinalis.*—Body fusiform, prolonged into a bifid tail, very common in the abdominal cavity of the *Batrachia* (Frogs and Newts). It moves in a straight line, oscillating from side to side.

Genus Heteromita, (D.)—Animals having globular, ovoid, or oblong bodies, with two filaments extending from the same point in front, one slender undulating, and producing an onward movement, the other thicker, stretching posteriorly, free, or contracting adhesion with the glass slide, so as to cause a sudden movement backwards.

The several sections of the *Monadina*, together with the *Thecamo-*

nodina and the *Euglenia*, contain *Infusoria* possessing two filaments, by one of which they progress, by the other adhere for support to any solid body, and produce a sudden movement backwards by its contraction. To prevent confounding specimens of these several families the same distinctions which mark the *Monadina* generally, must be found in order to constitute the *Heteromita* members of that family; such as the absence of integument, the gelatinous appearance of the entire mass admitting of agglutination to other objects, and the drawing out of its substance into filamentous processes, together with the existence of certain corpuscles, which can only have penetrated the interior as a consequence of the formation of vacuolæ at the surface.

Heteromita *ovata.*—Body ovate, narrower anteriorly, containing vacuolæ, granules and naviculæ. Length 1-1050th to 1-1150th. (P. 21. f. 5.)

This is probably the *Bodo grandis* of Ehrenberg. His other *Bodo's* are not *Heteromita*, but imperfectly observed *Cercomonads* or *Amphimonads.*

H. *granulum.*—Body globular, surface granular. Length 1-2600th. Found in rather putrid sea water.

H. *angusta.*—Body narrow, lanceolate, slightly bent, tapering at each end, with a flagelliform and another filament from the same point anteriorly, erect at the base, but floating freely the rest of its length. Length 1-1050th

This is a doubtful species. It is of the shape of a lanceolate leaf, with a mid-rib or longitudinal fold.

Genus Trichomonas, (D.)—Body ovoid or globular, capable of being drawn out when adherent, and in this way presenting sometimes a caudal prolongation, the anterior flagelliform filament is accompanied with a group of vibratile cilia.

T. *vaginalis.*—Body gelatinous, nodular, unequal, hollowed by vacuolæ, often adhering to other bodies; movement oscillating. Length 1-2600th.

T. *Limacis.*—Body ovoid, smooth pointed at each end and terminating in front by a flagelliform filament, from the base of which a row of vibratile cilia is directed backwards. Progressive movement active, the animalcule at the same time turning on its axis. Length 1-1730th. Found in the intestine of *Limàx agrestis.*

Genus ANTHOPHYSA, (D.)—Animals ovoid or pyriform furnished with a single flagelliform filament, and collected at the extremities of a branching stem, or polypidom, secreted by them. Groups when free resembling those of *Uvella*.

The tree-like polypary is brown at the base, but clearer and even diaphanous at the termination of the branches which appear nodular. The groups of animalcules are easily detached from the stem, and then commence a rotatory movement by the action of the filaments of each individual in the group. Detached solitary animalcules move like the common monads with a single filament.

The branching support at first soft and gelatinous, becomes by degrees more consistent, brown, and of a horny character, appearing to partake no longer the vitality of the animalcules.

Only one species is at present known and which is ranged by Ehrenberg under the genus *Epistylis*, along with *Vorticellina*.

A. *Mülleri* = *Epistilis? vegetans*, (P. 21. f. 2. Ehr.)

We conclude this family with two new genera, named by Werneck, (Monatsbericht der Berlin Akad. 1841. p. 377.) and thus briefly described.

Genus ANCYRIUM = *Enterodelous Bodo's*, (*i.e.* according to the nomenclature of Ehrenberg. *Bodo's* furnished with an intestinal tube,) with a moveable setacious foot.

The existence of an alimentary tube (so supposed), removes the *Bodo grandis* and the six allied species (*i.e.* the genus *Ancyrium*,) far above the *Monadina*, of Ehrenberg, whilst the possession of the setacious foot also indicates a higher organization.

Genus ERETES.—*Rudder Monads; Loricated Phacelomonads.*

FAMILY.—HYDROMORINA.

Characters. Anenterous Polygastrica without appendages; body uniform, like that of the Monads; but by reason of the spontaneous fission being imperfect, forming a moniliform mass or polypary, lorica absent. Individuals are at periods set free, which commence the same cycle of compound development as the parent being to which they originally belonged.

The genera belonging to this family, are, *Polytoma* and *Spondylo-*

morum. *Polytoma* was described by Ehrenberg in the family *Monadina*, but the subsequent discovery of the genus *Spandylonorum*, having the same general characters, and differing like it from the other monads, led him to create this new family *Hydomorina* to embrace the two.

Genus Polytoma. *The Partile Monads.*—Mouth truncated, furnished with a double flagelliform proboscis, situated, as with *Monas* and *Uvella*, at the anterior extremity of the body; eye and tail wanting. As the young increase in size, the parent body assumes a decussated or wrinkled appearance, like a mulberry, thus giving signs of its approaching self-division into *many sections* (as the name *Polytoma* denotes), or numerous individuals. It will not imbibe colouring matter; but its internal organization bears the usual evidences of the Polygastric nutritive system. Its only organ of locomotion is the double proboscis. A large contractile vesicle, sometimes observable within the creature, Ehrenberg conceives to belong to the male propagative apparatus. It increases by spontaneous self-division of its body, both transversely and longitudinally, thus dissolving, as it were, its berry-like cluster into many individuals. It was known to Müller and Wrisberg. One species has been recognized.

P. *uvella*. (*Monas uva*, M.)—Colourless, of an oval or oblong form, equally obtuse at both extremities. It is often abundant in water, where animal matters are in solution, upon which it appears to be nourished. It is generally in company with species of *Vibrio* and *Spirillum*, and sometimes with *Uvella uva*, and *U. atomus*, in water-butts.

Figures 8 and 9 represent two individuals; figure 10, another about to divide longitudinally; a cluster of eight is seen at fig. 7; and a matured one on the point of separating at figure 11. Figure 9 is magnified 800 diameters, showing the double proboscis very distinctly; and its body seems enveloped in an outer tunic (probably induced by the peculiar contraction), which disappears when the division is completed. Size from 1-200th to 1-900th. Diameter of clusters 1-380th.

Genus Spondylomorum.—The members of this genus are furnished with adorsal ocellus; are destitute of a tail, and in consequence of

their imperfect peculiar self-division, form a compound body (*polypary*,) resembling a whorl, or cluster of berries.

S. *quaternarium.*—Animalcules alternating in a group of four, of which the terminal one is the most slender; colour green; proboscides 4 to 5. Length of polypary 1-576th; of each animalcule 1-1728th.

Family.—CRYPTOMONADINA.

The family *Cryptomonadina* exhibits all the characteristics of the *Monadina*, (and no certain or definite ones of any other family,) they are besides furnished with a distinct gelatinous, membranous, or hard induvium, or shell-like substance, termed a lorica, in which they are more or less enclosed. Considering them as a family, their organization has been determined as completely as that of the *Monadina*, or even of the larger *Polygastrica;* although something more is yet to be learnt of the species individually. The lorica, or integument covering these creatures, is of different forms; sometimes having the figure of an open shield *(scutellum)*, at others of a closed box or a pitcher *(urceolus)*. Locomotive organs are clearly perceptible in all the genera, excepting, perhaps, the genus *Lagenella*, and even in this, Dr. Werneck is of opinion that he has discerned them. They consist of two delicate, filiform, and generally retractile processes, issuing from the margin of the mouth, and capable of being put into very powerful rotatory motion. We shall designate them, as with the Monads, proboscides. The nutritive apparatus of these creatures has not yet been demonstrated by the application of coloured artificial food; but with six or seven species (nearly one-half the family) internal cells have been discovered. In two genera, a sensitive system may be presumed to exist, from a coloured spot or eye-like appearance being present at the fore part of the body. From the position of this organ of vision, the dorsal line may be readily conceived, so as to indicate a right and left side of the creature. The individuals either self-divide simply and completely, or they do not divide at all. " It is possible," says Ehrenberg, " that the fossil animalcules discovered in the flint of chalk and porphyritic formations, and named by me *Pyxidicula* (see Plate 12, upper figures) belong to the genus *Trachelomonas*.

The genera hold the following relations :

Eye absent	Lorica obtuse and smooth	Form short, self-division longitudinal or wanting	Cryptomonas
		Form long and tortuous Self-division transverse	Ophidomonas
	Lorica pointed anteriorly		Prorocentrum.
Eye present	Lorica with a neck and narrow orifice		Lagenella.
	Lorica with the orifice but no neck.	Lorica an open shield (*Scutellum*)	Cryptoglena.
		Lorica a closed box or pitcher (*Urceolus*)	Trachelomonas.

"Of these genera," says Dujardin, "we accept but two, in bringing together the *Cryptoglena* and *Lagenella* as subgenera of *Cryptomonas*. *Prorocentrum* may be the same thing as our *Oxyrrhis;* and we, moreover, unite with *Trachelomonas,* the genera *Chætotyphla* and *Chætoglena,* placed by Ehrenberg amongst the *Peridinæa.* With respect to the genus *Phacus,* it has been introduced among the *Euglena* by this author, notwithstanding the difference existing in the non-contractility of its integument. Lastly, our genus *Diselmis* corresponds in part to the *Chlamidomonas* of the same writer."

Since there is a general correspondence between the family *Cryptomonadina,* of Ehrenberg, and that of *Thecamonadina* of Dujardin, we may append the account of the general characters given by the latter author of *Thecamonadina.*

The species of this family are readily recognized by the stiffness or inflexibility they display while swimming, or when brought into contact with other bodies. The lorica of the *Prorocentrum* and *Lagenella* is at once perceived to be a distinct covering. When any doubt, however, exists upon this point, a slight degree of pressure in the aquatic live-box, or between two slips of polished glass, will easily determine it. The lorica of the *Trachelomonas* is siliceous, and indestructible by fire.

Genus Cryptomonas. *The loricated Monads.*—This genus is essentially characterized (see the Table) by the species being destitute of the visual organ, and having a lorica obtuse, or not attenuated anteriorly. Body short, but not filiform ; self-division, if any, longitudinal ; flagelliform filament very fine.

Dujardin writes "In this genus *Cryptomonas,* I comprise all

Thecamonadina with a single filament, and with a lorica neither hard nor brittle, and whose body is not depressed like that of *Phacus* or of *Crumenula*, and I moreover do not doubt that when these Infusoria are better known, other genera may be distinguished by their more or less globular form, by the consistence of their envelope, and especially by their mode of existence. I already indicate as subgenera, *Lagenella* with an elongated lorica, and *Tetrabæna*, which live in groups of four, without, however, being united within a common envelope. As to the character supplied by the existence of a red speck in some individuals, assumed by Ehrenberg to be an eye, I cannot discover in it a generic distinction, nor am I able to recognize a lorica open on one side (below) like a shield. On the contrary, I have always observed the lorica to be closed and entire, though sometimes compressed on one side, adapting itself to the living mass enclosed. The covering in every case is evidently larger than the contained mass, a diaphanous space intervening between the two appearing like a ring."

Cryptomonas *curvata*.—Form compressed, slightly bent like the letter S, and twice as long as it is broad; colour green. Found amongst Confervæ. Size 1-570th.

C. *ovata* (*Enchelys viridis*, M.) Form depressed, oval, and twice as long as broad; colour green. Motion slow, vacillating, and rotating on the longitudinal axis: but when obstructed, the creature is seen to leap. Lorica paper-like, not hard, and the numerous internal transparent vesicles perceived amongst the green ova are the alimentary sacs. In the middle of the creature there are two or three egg-shaped bodies, supposed to be seminal glands, and at the posterior part a single variable vesicle of a sexual nature; self-division not observed. Figures 21 and 22 represent two full grown creatures (side and back view), magnified 300 diameters ; and fig. 23, a young one. Found amongst confervæ. Size 1-570th.

C. *erosa*. Body depressed oval, colour green, anterior part hyaline. Found in clean water, among confervæ, Size 1-960th.

C. *cylindrica* (*Enchelys viridis*, M.) Body elongated, sub-cylindrical, three times as long as broad. Found amongst confervæ. Size almost 1-1000th.

Cryptomonas (?) *glauca*. Form oval, twice as long as broad, an-

terior portion truncated with a double flagelliform proboscis. Body turgid, and of a blueish green colour. Found with the *Chlamidomonas pulvisculus*. Size 1-864th.

CRYPTOMONAS (?) *fusca*.—Oval, turgid, and of a brown-colour. Found amongst confervæ. Size 1-1500th.

C. *lenticularis*.—Form orbicular, resembling a lens; colour green; lorica thick. Size 1-1729th.

"The C. *curvata*"—says Dujardin, "is so compressed that it is properly referable to our genus *Crumenula*," The C. *glauca* and C. *fusca*, the same observer regards as doubtful species. The two following species are described, and named by Dujardin.

C. *globulus*.—Body globular, green, often with folds (stripes), nearly as large as the diaphanous envelope. Length 1-2600th., 1-2250th.

C. *inæqualis*,—Body ovoid, green, of less thickness than breadth, with a longitudinal depression, and one or two unequal notches in the coloured portion, which is always narrower than the envelope. Length 1-2600th. Found in stagnant sea water, imparting to it a green colour.

C. (LAGENELLA) *inflata*.—Body ovoid, enlarged posteriorly; contracted anteriorly; envelope transparent, thicker about the anterior neck-like portion; filled with a green substance, having a central red speck. Motion zig-zag. Length 1-1180th. Found in a vase of marsh water, with lemna.

Ehrenberg has described under the name of *Lagenella euchlora*, an Infusorian of the same size, differing from ours by its more elongated form, and especially by the green contents, more completely occupying the anterior neck-like portion, whereas in ours but a narrow streak is visible.

C. (TETRABÆNA) *socialis*. Body ovoid, regular, green, with a central red point, enveloped by a thick lorica, which is diaphanous, and often exhibits a commencing self-division. Animals living, collected in regular groups of four individuals, simply agglutinated, and having their filaments directed all to the same side. Length 1-1700th, 1-1300th. Found in a water-butt, in the King's garden, Paris.

"I should have taken the specimens at first for *Gonia*, if a trace

of a common enclosing envelope, had been found; yet I cannot doubt, but that they have the closest analogy with true *Gonia*, and with what Ehrenberg has called *Syncrypta* in his family *Volvocina*. One may suppose that the commencing self-fission observed in some individuals would give rise to such groups, upon the destruction of the lorica (integument) in these different genera. This mode of propagation occurs, undoubtedly, in most of those having a soft gelatinous integument, but in animals like *Trachelomonas*, whose lorica is hard and brittle, we cannot understand how multiplication does take place."

In the addenda to his treatise, Dujardin has this remark, "I am convinced that my *Cryptomonas* (*Tetrabæna*), belongs rightly to Gonium."

Genus OPHIDOMONAS. *The serpent Monads.* The distinguishing characters of this genus are its filiform body, absence of the eye, its smooth and obtuse lorica, and its transverse but complete self-division. It was discovered by Ehrenberg in September, 1836. It is furnished with a filiform proboscis, as its organ of locomotion, which, together with the tubular lorica, and the numerous digestive sacs, form the whole of the organization that has hitherto been demonstrated. Its extremely small transverse diameter is the great impediment to a better acquaintance with this creature. Whether its brown colour is derived or not from the ova within it has not been determined. (It has not been figured.)

O. *Jenesis.*—Form very thin, curved spirally, and equally obtuse at both extremities; colour olive-brown; motion brisk. Found only at Jena, in well water. Size 1-570th.

O. *sanguinea.*—Very slender the interspaces between the stomach—sacs filled with a red colour. Size 1-576th. inch. Found near Cilonium, in brackish water.

Genus PROGNOCENTRUM. The *pointed-shell Monads.*—The animalcules of this genus are destitute of the eye, and have a smooth lorica, resembling a little box (*urceolus*), pointed at the anterior extremity. They have a filiform proboscis, and numerous large digestive cells in the anterior of the body. Self-division has not been observed. "It is worthy of remark," says Dr. Ehrenberg, "that the only species of this genus with which we are acquainted (*i.e.* in 1838), belongs to

the luminous creatures of the sea, which, perhaps from some peculiar organic relation or condition, yet unknown to us, are instrumental in producing that curious and certainly vital phenomenon usually termed phosphorescent sea." It may be further noticed, that all the luminous Infusoria of the sea, hitherto discovered, are characterized as being of the same yellowish waxy colour as the species of this genus; and it is probable that this condition is immediately connected with the interesting phenomenon in question.

PROROCENTRUM *micans.*—Form oval and compressed, attenuated at the posterior part, but dilated and pointed anteriorly; colour of yellow-wax. Found in sea water. Figures 24 and 25 exhibit two animalcules magnified 300 diameters; the first is a side view, the latter a back view. The proboscis in figure 24 indicates the position of the mouth. Size 1-430th.

P. *viridis.*—Figure ovate, suborbicular, turgid; posterior end rounded; anterior shortly pointed; colour green. Size 1-1100th. Found in the Baltic sea.

Genus LAGENELLA.—*The flask-shaped Monad* is distinguished from the other loricated Monads by its closed shell being so extended anteriorly, as to give it a neck-shaped appearance, like that of a bottle or flask. This shell or lorica is perfectly distinct, and as clear as crystal. The only part of the organization of the creature at present known is the eye, or bright red speck, which is always to be seen in this genus, and the green granules within the body of the animalcule, which Ehrenberg supposes to be ova.

T. *euchlora.*—Form oval, neck short and truncated; lorica crystalline; colour of the body or eggs green. Figures 26, 27, and 28, are representations of this creature magnified. Found amongst confervæ. Size 1-1200th.

Genus CRYPTOGLENA. *The loricated Monads with an eye.*—This genus is distinctly characterized by the species having an open lorica. of the form of a shield (*scutellum*), but folded or rolled inwardly at the sides, and without the projecting neck. The eye is perfectly evident, and the small digestive cells appear to be covered with green egg-like granules. In the species *C. conica*, traces are seen in the centre of the body of a male generative apparatus, in the form of two oval glandular masses, of a greyish colour; in this species also a

double filiform proboscis is seen. Self-division has not been observed in any of the species, which are all of a green colour.

CRYPTOGLENA *conica.*—Form conical, anteriorly dilated and truncated, and furnished with two filiform proboscides, half the length of the body; posterior acutely attenuated. Colour a bluish green. Group 29 is a magnified representation of three creatures. They are found in great numbers in butts of river water, in company with the *Cryptomonas glauca*, from which they are readily distinguished by their form, larger size, and red eye. They move briskly in the direction of the longitudinal axis of their bodies, but when obstructed, they spring or leap out of their course. Size 1-1100th.

C. *pigra.*—Form oval, approaching to globular, and emarginate anteriorly; colour a beautiful green; movement slow. Found in water, when covered with ice. Size 1-3000th.

C. *cærulescens.*—Form depressed, elliptical and emarginate anteriorly; colour bluish-green; motion quick. Found amongst confervæ. Size 1-6000th

Genus TRACHELOMONAS. *The Monads with the trunk.*—This genus comprehends those loricated animalcules of the family *Cryptomonadina* which are possessed of the visual organ, and of a closed box-like elongated or spherical lorica, but without the projecting neck. They are furnished with a single long filiform proboscis or seta, for the purposes heretofore described, and in two species, *T. nigricans*, and *T. volvocina*, very minute transparent vesicles have been discerned, which are most probably their digestive sacs. In the species *T. cylindrica*, egg-like granules are visible. Two species are green, and one blackish-brown. It is most probable that those highly interesting animalcules which enter so abundantly into the silicified substances in certain chalk formations belongs to this genus.

T. *nigricans.*—Form oval, approaching to globular; colour rarely green, mostly of a reddish or blackish-brown. Eye brown. Size 1-1700th.

T. *volvocina.*—Form sperical; colour mostly green, sometimes of a brownish hue, but easily distinguished by a red ring on the circumference of the body; vesicles may be observed internally, which are most probably the digestive sacs, between which a very fine granulated

substance is situated, producing the colour of the body. It is furnished with a delicate flagelliform proboscis. The red circle, so remarkable a feature in this species, always appears to abide in the same horizontal position, how quickly soever the creature may be revolving on its longitudinal axis. Figure 30 represents this creature with its proboscis extended; figure 31, another with it retracted; figure 32 is a very young specimen; and 33, a full grown one, that has been pressed between two plates of grass, so as to exhibit the lorica broken without destroying any part, except the red circle above noticed. Found amongst confervæ. Size 1-860th.

Trachelomonas *cylindrica.* Form oblong, approaching to cylindrical; proboscis almost as long as the body. Colour a beautiful green; eye red; ring purple. Size 1-1000th.

T. *arceolata.* Form of lorica globose, surface areolated.

T. *aspera.* Figure of lorica similar to preceding, but its surface covered with rough points.

T. *granulata.* Similar, but its surface very minutely granulated.

T. *lævis.* Lorica also globose, with its surface smooth.

T. *pyrum.* Lorica oblong or pear shaped (pyriform) smooth.

Dujardin, in his family *Thecamonadina,* includes some genera of animalcules not described by Ehrenberg, or otherwise, described under different names and a diverse arrangement. They are appended here as best agreeing with the *Cryptomonadina.*

Genus Phacus. (D.) Body flattened and leaf-like, mostly green, and displaying a red speck in front, together with a flagelliform filament, and a resistant membranous integument prolonged posteriorly in the form of a tail.

This genus comprehends some animalcules, referred by Ehrenberg to his genus *Euglena,* on account of similarity in colour. The difference between the two genera is, however, considerable, for in *Euglena* the integument is contractile, and permits of a frequent change of form, whilst in *Phacus,* on the contrary, the integument appears quite wanting in contractility, and the animal invariable in form.

The enclosing integument of *Phacus* persists after the death of the animal; after the destruction of the contained green mass, and also after the action of various chemical agents, becoming, in the latter

cases, quite transparent. The motor filament, however, disappears with the living contents; but globules of the latter, indeed, remain after death.

The optical character of the red speck in the individuals of this genus is denied by Dujardin, as also the existence of a mouth, stomach sacs, and sexual glands, supposed by Ehrenberg, who has described three out of the four species of *Phacus*, adduced by the French naturalist, as specimens of *Euglena*.

Thus, 1. *Phacus pleuronectes* = *E. pleuronectes*. 2. *P. longicauda* = *E. longicauda*. and 3. *P. triquetra* = *E. triquetra*. (See Euglena.)

The new species of which the characters are given is :—

Phacus tripteris. Body oblong with three longitudinal plaits meeting along the axis, rather twisted on the mid rib, with a red speck in front and a diaphanous caudiform prolongation behind. Length 1-420th, 1-312th.

Genus Crumenula. (D.) Body oval, compressed, clothed with a resistant integument (testa) obliquely situated, and, as it would seem, reticulated, sending out obliquely from a notch in the anterior border, a long flagelliform filament. Motion slow. There is no tail like prolongation as in *Phacus*.

C. *texta.* Envelope resistant, reticular, filled with a green matter, together with vacuolæ or hyaline globules, and having a large anterior red globule. Length 1-520th. Testa persistent after death. (P. 21. f. 6.)

The anterior notch is produced by a sort of overhanging lip. The filament is three times longer than the body.

Genus Diselmis. (D.) Body ovoid or globular, covered by an integument, of almost a gelatinous consistence, but not contractile, and provided with two equal locomotive filaments.

This genus nearly corresponds to the *Chlamidomonas* of Ehrenberg, placed by him in the family *Volvocina*, by reason of its apparent self division, into two or four segments within the testa. Dujardin, on the other hand, admits none as *Volvocina* which do not exhibit an aggregation of perfect individuals within a common envolope.

The integument of *Diselmis* is non-resistant, diaphanous, breaking up after death, it is sometimes filled with a green substance, according to Ehrenberg, coloured ova, an improbable supposition in

Dujardin's opinion, seeing that these beings are sensitive of light and, like plants, fix themselves to the lightest part of the containing vessel, and disengage gas (oxygen) when exposed to the sun's rays. In the green substance are seen granular masses, a disc with enlarged border and a red speck. The motor filaments proceed from the same opening of the integument, and often form a diaphanous lobe projecting from the opening. The red colour seen oftentimes in the water of the Mediteranean appears due to Infusoria of this genus.

DISELMIS, *viridis* = *chlamidomonas pulvisculus*, (Ehr.)

D. *marina*.—Body nearly globular, obtuse, and rounded in front, granular within. Length 1-1050th.

This species is larger than *D. viridis*, more globular, and apparently deficient of the red speck. Found in stagnant sea water of a green colour.

D. *Angusta*.—Body pyriform, oblong, appearing to be plaited, and tubercular inside, sometimes with an indistinct red speck. Length 1-2600th to 1-1850th.

D. *Dunalii*.—Body oval or oblong, often constricted about the middle; colourless when very young, then green, afterwards red, two flagelliform filaments longer than the body, seated on a projecting and retractile anterior lobe. Interior occupied by coloured globules. Discovered by M. Joly, to be the chief cause of the red colour of the water of the Mediterranean Sea.

Genus ANISONEMA.—Body colourless, oblong, more or less compressed, having a resistant envelope, giving exit by an opening to two filaments, one directed forwards flagelliform, the other trailing backwards and retractile; movement slow.

In other genera, as in *Heteromita*, two similarly characterized filaments exist, but the present genus is known by its non-contractile resistant integument, which is often met with empty and transparent. It may be that the *Bodo grandis* (Ehr.) is allied to this genus as well as to *Heteromita*.

A. *acinus*.—Body oblong, depressed, rounded posteriorly narrower in front, like the seed of an apple, with an opening close to the apex; movement in a straight line forwards. Length 1-1300th to 1-850th. In pond water.

A. *sulcata*.—Body oval, depressed, with 4-5 longitudinal furrows,

and an oblique notch in front, from which the two filaments proceed; movement vacillating, circular. Length 1-1300th. The projecting filament is three times, and the floating one about twice as long as the body. (P. 21. f. 8.)

Genus Plœotia, (D.)—Body diaphanous, having several ribs or longitudinal ridges at the middle, and a circular translucent margin, giving the whole a navicular form; two locomotive filaments proceed from one end.

This distinct form of Infusoria might be mistaken for one of the *Bacillaria*, were not the filaments clearly visible. The characters of the filaments are similar to those of *Anisonema*, one extending forwards with an undulatory movement, the other trailing and capable of suddenly arresting the movement of the body by its adhesion and power of retraction.

P. *vitrea*.—Body hyaline, with 3-4 longitudinal salient lines at the centre, and some granules. Length 1-130th; movement slow. Found in sea water, kept for two months. (P. 21. f. 10. *a. b.*)

Genus Oxyrrhis, (D.)—Body ovoid, oblong, obliquely notched in front, and prolonged into a point, several flagelliform filaments proceed laterally from the bottom of the fissure.

The name indicates its elongated apex; one species only is described; these Infusoria being but imperfectly known.

O. *marina*.—Body colourless; sub-cylindrical rugose, rounded posteriorly. Length 1-520th. (P. 21. f. 9. *a. b.*) Found in the Mediterranean.

Family.—VOLVOCINA.

This family derives its name from the *rolling motion* with which the extraordinary creatures belonging to it make their way through their natural element—the water. The mode in which they self-divide, whilst pent up within their loricated vestment, is a curious characteristic of the family, and such as would almost warrant the supposition that they hold some very near relationship to those remarkable creatures termed *Zoophytes*. They resemble the *Monads* in most particulars relating to their organization. The body is unvarying, and except cilia, destitute of appendages. They have several digestive sacs, but no true alimentary canal. Whilst propagation by self-division

is proceeding, and the young are increasing in size, the surrounding induvium, which is a distinct lorica, is observed to expand in a corresponding degree, but continues entire until its numerous occupants have come to maturity, when it is seen to burst, and set them at liberty. The animalcules thus set free multiply in the same manner, and also by means of ova—in which case the expansive property of the lorica comes equally into operation.

All the genera (excepting, perhaps, *Gyges*), are provided with organs of locomotion, which consist, as with the *Monads* and *Cryptomonads*, of a single or double flagelliform very delicate proboscis; and hence it is that, when they are in clusters, the entire group appears to be ciliated, or beset with hairs. Transparent digestive cells are visible in the *Volvox globator* and *Gonium pectorale*, but in most of the species the green ova hide them from our sight. The propagative apparatus is evident in all the genera, with the exception of the *Uroglena*, under the form of ova grains, one or two round glands, and a contractile bladder.

The family is disposed into ten genera: five are furnished with the visual organ, situated at the anterior part of the body, and five are without it. In the former, a sensitive system is consequently presumed.

The following is an analysis of the family:—

Eye absent.	Tail absent	Lorica single	Lorica box-like	vibrating proboscis absent	Gyges.
				vibrating proboscis present	Pandorina.
			clusters tabulated or in plates		Gonium.
		Lorica double			Syncrypta.
	Tail present				Synura.
Eye present	Self-division both equal and perfect (no internal globes)	tail present			Uroglena.
		tail absent..	proboscis single		Eudorina.
			proboscis double		Chlamidomonas.
	Self-division unequal (forming internal globes)	proboscis single			Sphærosira.
		proboscis double			Volvox.

There is a tendency in recent observers to refer many, or even all of the *Volvocina* to the vegetable kingdom. For instance, Dr. Carpenter says, "It is not by any means certain that the *Volvocina* are

not to be transferred to the vegetable kingdom. Their green colour leads to the suspicion that they decompose carbonic acid, and the stomachs described by Ehrenberg in the component Monads, are not more distinct than the stomachs which he has represented as existing in several other beings, whose vegetable nature is now generally admitted. It is considered by Braun, who has paid much attention to the development of inferior Algæ, that the *Vlovocina* are of the same type with certain *Zoospores*, which become composite by fissiparous multiplication."—*Principles of Physiology*, p. 251.

Dr. Carpenter's reviewer, in *The British and Foreign Medico-Chirurgical Review*, October, 1851, writes, "We have recently seen a series of preparations by Mr. Williamson, of Manchester, who has paid much attention to the development of the *Volvox*, which leave not the slightest doubt in our minds that the entire hollow sphere is originally composed of cells formed by the multiplication of a single one; and that these cells are of the same essential character with those of the inferior Algæ generally; it being a part of their nature to secrete a great thickness of pellucid mucilaginous matter around the primardial utricle, [The delicate living membrane of the walls of cells is so called by Moehl, and is considered of special importance in cell-formation.] And thus the green utricles (cells), which are originally in close approximation, become separated from each other by its intervention, still remaining connected, however, by certain thread-like prolongations, which Ehrenberg has erroneously described as vessels."

While it is a duty due to the reader to insert the above opinions on the *Volvocina*, my observations, for more than twenty-five years, on these creatures, induce me firmly to believe in their animal nature.

Dujardin, whilst admitting the *Volvocina* among true animal Infusoria, would effect a different distribution of the genera proposed by Ehrenberg. *Gyges* and *Chlamidomonas*, would transfer to the *Thecamonadina*, *Cryptomonadina*, (Ehr.), inasmuch as they do not present an aggregation of individuals enclosed by a common envelope. Further, since the visual character of the red specks is not admitted by the French naturalist, *Eudorina* and *Pandorina* must be combined, as also *Synura* and *Uroglena*, whilst the genus *Syncrypta* is ren-

dered doubtful, and, probably *Sphaerosira* should be united with the *Pandorina*.

Genus Gyges. *The ring Animalcule.*—This genus is characterized by being deficient of the eye, tail, and vibrating filiform proboscis. The lorica is of a simple box-like form *(urceolus)*. We know but little of the organization, as not even the nutritive apparatus has been observed; and were it not that some slight spontaneous motion of the body is perceptible, when it is surrounded with a coloured fluid, it would seem that all the certain characteristics of an animal were wanting. Two species are mentioned by Ehrenberg, both of a green colour, and enclosed in a transparent lorica.

G. *granulum (Volvox granulum,* M.*)*—Form oval, approaching to globular. Body contains a heap of granules within it, of a darkish-green colour. Found amongst Lemna and Conferva. A magnified representation is given at figure 34. Size 1-1150th.

G. *bipartitus.*—This species has a body of a crystalline gelatinous substance, and of nearly a spherical form; the superficies colourless, but its contents yellowish-green. Its body is sometimes divided into two, and at others it is a simple sphere. The contents are composed of numerous homogenous granules, which if the creature be an animal, may be considered as the ova. Found amongst Conferva. Size 1-480th.

G. *sanguineus.*—Body oval, colour red, inclining to crimson, surrounded by a broad colourless ring, representing an enveloping lorica. This is a new species discovered by Mr. Shuttleworth in the red snow, which fell at the Grimsel, in August, 1839; its motion is lively. In Plate 12., group 527, shows several highly magnified. Found with *Astasia nivalis* and *Monas gliscens,* among the globules of *Protococcus nivalis.* (See *Ed. Phil. Jour.* v., xxix., also Dr. Cöhn's elaborate Essay.) Length 1-1200th to 1-300th.

M. Vogt has described the reproduction of this being as very singular. He says, "it gives off from several parts of its body small transparent buds, apparently vesicular, and, for the most part, filled with granular matter. As they enlarge they become gradually detached; sometimes two of equal size, of which one is red and loricated, the other colourless, adhere by a very narrow point of attachment, which subsequently gives way, and the bud appears as an Infusory

animal, like what Mr. Shuttleworth has represented in his 7th and 8th figures, and which approaches *Pandorina hyalina.* (Ehr.)"

M. Vogt adds, that *Gyges sanguineus* ought not only to be looked upon as the type of a new genus, but even of a new family, on account of its very peculiar mode of reproduction.

He further describes a new Infusorium, as a species of *Gyges*:—

GYGES *Vogtii.*—It occurs as a globular organism, containing in its interior from 2 to 5 individuals, enveloped by an apparently siliceous lorica. The colour is dark red; the globules are frequently found adherent, and arranged in the form of a cross; they are also often separate. "The small individuals, probably the young, were of a clear yellow hue. I could not observe the slightest motion in them." On the Animalcules of the Red Snow.—*Bibliothéque Univers de Genève,* May 1841.

Genus PANDORINA. *The berry-like globe Animalcules.*—The characteristics of this genus are, its being destitute of eye and tail, but provided with the box-like lorica, of a globular shape, and with a filiform proboscis. During the process of self-division the internal development gives the creature the appearance of a mulberry. A simple proboscis is present in all the species (at least in all the European) as the organ of locomotion, &c., and transparent vesicles, seemingly the nutritive apparatus, may be observed. There are two species only, one green, and the other colourlesss; the latter, however, is a doubtful *Pandorina.*

The following characteristics as given by Dujardin, appear more clear than those of Ehrenberg.

The *Pandorina* consist of very small green animals, grouped into globules imbedded in the interior of a gelatinous mass, diaphanous, and ovoid, or globular, in figure.

Unlike *Volvox,* in which the individual animalcules occupy the surface, those of the *Pandorina* are surrounded by a transparent sphere, and the mode of the propagation being also different, no formation of internal globes, and their ultimate escape by rupture of the enclosing parent, is seen to occur.

Pandorina elegans—Endorina elegans. (Ehr.) Dujardin esteeming the presence of the red speck (supposed eye) to be insufficient to characterize a genus.

PANDORINA *morum* (*Volvox morum*, M.) Body simple or multipartite, enclosed within a simple lorica. Colour green; proboscis twice as long as the body. Figure 37 represents a cluster; 36, a single animalcule; and 35, one in which self-division has just commenced. Found in water with Lemna and Conferva. Size of individual, 1-1150th; ditto cluster, 1-120th. Individuals broken from the cluster by Ehrenberg have not been above one-third the former measurement.

P. *hyalina*. Form globular. Found in the Nile with conferva. Size 1-5760.

Genius GONIUM. *The tablet Animalcules.*—The members of this genus are especially characterized by being deficient both of eye and tail, by having a simple lorica, and by developing themselves in the process of self-division in clusters, of a regular four-cornered tablet or plate. The lorica of each individual (as is noticed after separation) is nearly round, and resembles a mantle (*lacerna*), which the creature is empowered to cast off, and form anew. In one of the species (G. *pectorale*) two filiform and vibratory proboscides are placed at the mouth, as organs of locomotion, &c.; in the other species, these have not been observed. Vesicles are seen within G. *pectorale*, notwithstanding the creature abstains from coloured food; and a red speck (produced probably by inflected light) at the base of the proboscides has been perceived by Ehrenberg, which he conceives to be the mouth.

G. *pectorale* (M).—The form of this animalcule, or more correctly, cluster of animalcules, is shown at figs. 38, 40, and 41. It consists of sixteen spherical bodies, enclosed within a transparent lorica or shell, and disposed regularly in a quadrangular form, like the jewels in the breast-plate of the Jewish High Priest. They are all arranged in the same plane. The four centre ones are generally larger than those which surround them, and the combined diameters of the three smaller balls, are about equal to the two larger centre ones to which they are attached; the external corners are consequently vacant. As these animalcules swim and revolve in the water, they occasionally present a side view to the observer, when the circumference of the larger central globules may be seen projecting beyond the others. Sometimes the clusters appear irregular; this

happens when the larger animalcules have arrived at maturity, and some of them have separated from the cluster. When they are all of equal diameters, the group divides across the middle, both vertically and horizontally, and separates into four clusters, each consisting of four animalcules. As soon as a cluster has separated, the respective animalcules increase in size, and in a short time their surfaces appear decussated, and they severally begin to form into regular clusters, like the original one to which they belonged. They are of a beautiful transparent green colour, and in swimming, the globules often appear of an ellipsoidal figure (see fig. 40); their forms, when viewed under the microscope in the usual way, are so simple, and so different from animated beings cognizable to unaided vision, that it would be difficult to bring our reason to admit of their vitality, were not their spontaneous motion clearly ascertained; and when examined under a high magnifying power, with proper illumination and management, their structure rendered apparent. Figure 39 shows a single free animalcule, with its two proboscides, and figure 42, a highly magnified view of another, invested with the lorica. In this figure is seen the disposition of the six cords or tubes which connect it with the surrounding ones; also numerous corpuscles within the body. A combination of sixteen animalcules (never more, but sometimes less) generally forms the square tablet or plate.

In order to observe the structure of this highly curious and beautiful creature, considerable adroitness is necessary in the management of the microscope, while, a little indigo, conveyed into the water with the point of a camel's hair pencil, will be required to see the whorls and currents set in motion around it. It is almost incredible what power, comparatively speaking, these minute beings possess, notwithstanding the speck they appear to occupy in the scale of creation. The currents are produced by the proboscides, two of which, as stated above, are situated at the mouth of each individual, so that in a tablet or plate, thirty-two, in all—twenty-four placed at the edges, and eight standing out from the centre—are brought into action.

The single animalcules (fig. 39) swim like the Monads, in the direction of the longitudinal axis of their bodies, with the mouth foremost, but the plates have a variety of movements; sometimes

they move quite horizontally, at others vertically, and then again on their edges, revolving like a wheel. A magnifying power of 200 diameters is sufficient for general examination; but to exhibit all the structures shown in the engravings, four times that power will be required. Found in clear water, salt and fresh, near the surface. Discovered by Müller, in clear water, at Copenhagen, 1773. Size of animalcule from 1-460th to 1-1150th; ditto of tablet, not exceeding 1-280th.

GONIUM *punctatum.* Body composed of green corpuscles, spotted with black, and enclosed within a crystalline lorica. Found amongst conferva. Size of animalcule 1-4600th; a tablet of 16, 1-570th in breadth.

G. *tranquillum.* Body composed of green corpuscles within a crystalline lorica, as shown at figure 43. Size 1-2880th; a ditto tablet of 16, from 1-140th to 1-220th in breadth. Tablet sometimes twice as broad as long.

G. *hyalinum.* Body composed of transparent corpuscles within a crystalline shell. Found in stagnant water. Size 1-300th; ditto tablet of 20 to 25, 1-6000th in breadth.

G. *glaucum.* Body composed of blueish-green corpuscles within a crystalline shell. The tablets vary in the number of animalcules—namely, from four to sixty-four. Found in sea water. Size 1-5000th; ditto tablet, 1-500th in diameter.

Genus SYNCRYPTA. *The double loricated globe Animalcules.*—This genus of the family *Volvocina* is mainly characterized by its secreting or hiding itself (as the name implies) within a second envelope or shell. The individuals of the genus are each of them provided with a special lorica of their own, of the form of a little shield (*scutellum*), but being of a social character, they have besides a common envelope or gelatinous mantle *(lacerna)* into which they retreat or aggregate, as occasion may require. They are deficient of both eye and tail, but they have a large filiform proboscis, which vibrates, for the purposes of locomotion, &c. When the animalcules are in a cluster, these proboscides give it an appearance of being surrounded with hairs. The digestive sacs have not yet been perceived. Self-division takes place in a longitudinal direction.

With this genus Dujardin would identify his *Cryptomonas* (*Tetrabæna*) p. 144.

SYNCRYPTA *volvox*. Body of an oval form and green colour, with whitish rays in the centre. Found generally in water drained from Conferva. Size 1-2880th; ditto of a clustered globule in its crystalline tunic, hardly exceeding 1-570th.

This berry-like cluster of animalcules, when rolling through the water, is a beautiful object for the microscope, and, with the aid of a little indigo, the numerous currents it creates are readily perceived. The usual appearance of the clusters, as viewed under the microscope, and amplified 260 diameters, is given at fig. 45. Fig. 44 represents a cluster magnified 400 times, and fig. 46 a cluster as viewed by Ehrenberg, in its simplest state, when about to sever into four.

Genus SYNURA. *The ray globe Animalcules* are characterized by being destitute of the eye, but provided with a filiform tail, which is attached either to the base of its own lorica, or to the centre of the cluster to which it belongs. The general envelope is a gelatinous substance of a spherical form, and fitted up into as many compartments, or cells, as there are individuals in its little community. From out of these cells they can severally stretch themselves a considerable distance, whilst they continue fastened, in the manner before described, by the extremely delicate and extensible tail.

S. *uvella*. Composed of oblong corpuscles, of a yellow colour; capable of being stretched forth from their cells to three times their natural length, by means of the extensible tail. The cluster has the form of a mulberry, and its motion is a rolling one, like that of the *Volvox globator*. Figure 50 exhibits a cluster magnified, and figure 51 a portion of a cluster, to show the manner in which the tails of the animalcules are inserted in the common envelope. This species, along with *Syncrypta* and *Uroglena volvox*, may often have been confounded with *Uvella virescens*. Length of body, exclusive of tail, 1-700th; diameter of cluster, from 1-190th to 1-280th.

Genus UROGLENA. *The globe Animalcules, with ray and eye.*—This is the first genus of the family *Volvocina*, which is distinguished by the possession of both the eye and tail. It is also a sort of compound animalcule, living in clusters under a common covering or mantle *(lacerna)*, which is apportioned into cells for the accommodation of the several individuals. Self-division takes place simply and equally in these individuals, whilst remaining in their clustering condition. Within the mantle they are placed at uniform distances from each

other, with their tails radiating from the centre, and by means of which each animalcule is fixed to the base of its own special envelope. Each one is furnished with a filiform proboscis, which gives to the entire group the appearance of being covered with hairs. When the creatures divide, the mantle or lacerna, only enlarges, without becoming separated itself. The visual organ is a red speck in the fore part of the body; the tail is filiform, resembling that of *Vorticella and Bodo.*

The internal structure of these compound animalcules can be verified only with instruments of superior quality, and require considerable skill in the management of them. This latter qualification is so indispensable, that notwithstanding many persons in this country possess better microscopes than those employed by Ehrenberg, the curious organization of these little creatures has hitherto eluded their observation.

Uroglena *volvox.*—Body composed of yellow corpuscles of an oblong form. Tail extensible from three to six times the length of the body, and even more. Cluster mulberry-shaped. There is little doubt but that single animalcules of this genus, seen in company with the clusters, have often been taken for creatures of a different family. Ehrenberg states that he has observed individuals with two or three eyes, which he conceives to have been a symptom of approaching self-division. Fig. 54 gives a magnified representation of a globular cluster of these animalcules, and fig. 53 a single one, in which the red eye is distinctly visible. Found in turf water. Diameter of cluster. 1-90th.

Genus Eudorina. *The globe Animalcule with an eye.*—The characteristics of this genus are its absence of tail, but possession of the eye, which may be distinctly seen, and a simple filiform vibratory proboscis, situated at the mouth, as its organ of locomotion, &c. Self-division is also undergone by the individuals simply and equally, whilst retaining their clusted position. These little creatures are endowed with the power of periodically casting off their globular lorica or mantle (*lacerna*) which envelopes the cluster, and exuding a new one, like certain animals of the class Annelida. To observe the eye a power of 300 diameters must be skilfully employed.

E. *elegans.*—Composed of green corpuscles, of a globular shape,

never protruding out of their cells from the common envelope. Eye sparkling red. The clusters which are of an oval or globular form, contain generally from 30 to 50 individuals, and never less than 15. Motion rotating. Figure 47 is a cluster magnified; it exhibits the proboscides extended, and the bodies of the animalcules within the lorica. Clusters of these beautiful animalcules are often seen in such amazing numbers, along with the *Volvox globator* and *Chlamidomonas pulvisculus*, as to render the water (otherwise colourless) of a decided green colour, especially towards its edges. They are exceedingly delicate, so much so, that it is difficult to preserve them alive for more than a day or two: whenever it is attempted to retain them in large quantities, the second day will generally exhibit a thick mass of dead ones at the bottom of the vessels. When a few only remain alive, if the water be poured away, and the creatures removed into a vessel of clear water, they will live for weeks. Found at Hackney and Hampstead; most abundant in the spring of the year. Diameter of cluster 1-180th.

Genus CHLAMIDOMONAS. *The cuiras Monad Animalcules* are characterized by being deficient of the tail, but provided with a beautiful red eye, indicating a sensitive system, and with a double flagelliform proboscis, for the purpose of locomotion, &c. The shell-like envelope, which bears the form of a little box (*urceolus*) encloses the creature up to the mouth, and when the young have attained to maturity and self-division is to be completed, it bursts, to set them at liberty. The lorica is with difficulty perceived upon the young ones.

C. *pulvisculus* (*Monas pulvisculus*, M.)—Body composed of green corpuscles, of an oval form, and included within a box-like shell. Eye brilliant red, and proboscis double. The clusters are globular, and made up of only three or four, or at most eight? Group 52 represents a single one; also a cluster about to separate into five, the latter enclosed in a common envelope. See *Diselmis viridis* (Duj.)

These creatures form the larger portion of the green matter which colours the water contained in water-butts, ponds, and puddles, in the summer and autumn, and especially after a storm. It could hardly

fail to have been observed so soon as any of this green water was examined under the microscope.

Wherever these creatures exist in great quantities, multitudes of them die; their bodies, and the envelopes cast off by the living ones, are decomposed, gaseous matter is generated, which adhering, causes them to rise to the surface of the water, forming a green stratum upon it. Although the animalcules, and their coverings, when in this state, somewhat resemble *Ulvaceæ*, yet are they easily distinguishable from them by the red speck or eye, which is retained for a considerable time after death, and the new bodies may be seen connected together by means of an intervening membrane, formed of dead colourless Infusoria, and the remains of loricæ. Size 1-550th.

Genus Sphaerosira. *The rudder Animalcules.*—The distinguishing features of this genus are its being deficient of the tail, but possessing the eye, and a simple filiform rudder-like proboscis. Its method of self-dividing is different from that of any of the preceding genera, inasmuch as it occurs unequally within the envelope, when young clusters are formed at once from the parent ones. This genus differs, then, from *Pandorina,* in having the eye; from *Eudorina,* by its unequal mode of self-division; and, from *Volvox,* by its simple proboscis. Self-division in these creatures takes place in the longitudinal direction, commencing in parallel planes, so that lamina are produced as with the *Gonium.* Since, according to Dujardin, but one filament exists in *Volvox,* this genus should be set aside as indistinguishable from the latter.

S. *volvox,*—Body composed of pale green corpuscles, of nearly a globular shape, enveloped in a lorica of the mantle form. Eye bright red. The cluster resembles a great ball of animalcules, containing small compressed clusters within it. Fig. 49 represents a portion of the tunic or lorica, highly magnified, so as to shew the different forms of the creatures located within it; thus, three single animalcules, one mulberry-shaped cluster, and one oblong group may be observed within that portion of lorica. Figure 48 represents a large spherical cluster. Found in considerable numbers in company with the *Volvox globator*, and often attains its size. Sometimes found by itself.

Genus Volvox. *The globe Animalcules.*—The genus *Volvox*, which

is the type of the family *Volvocina,* was instituted by Linneus, and promulgated to the world in 1758, in the tenth edition of his *Systema Naturae.* This genus, as first described by him, comprehended the entire race of Infusoria, excepting only eleven of the tribe *Vorticella,* which were separated from them, under the denomination of Hydra, the two species *V. globator* and *V. chaos* containing all the rest. In his twelfth edition (1766) of the same work, he distributes the Infusoria into four genera, viz., *Vorticella, Volvox, Hydra,* and *Chaos.*

Volvox is characterized by the members aggregating under a transparent shell-like lorica, of the form of a hollow globe, the creatures being distributed over the internal surface of it. Each animalcule possesses the red eye and a double filiform proboscis, which latter protrudes beyond the surface of the lorica, so as to give it the appearance (where great numbers of these creatures are assembled to form the globe) of being covered with cilia. The different modes of increasing by self-division are especially characteristic of the genus.

Formerly the whole globular mass was regarded as a single warty or ciliated animalcule, and the bursting of the globe, whereby a few inner globes, which had come to maturity and previously left their positions in the lorica, were liberated, was considered as the birth of the single animalcule. This theory Ehrenberg clearly proves to have been erroneous, and shows that a somewhat deeper research is necessary in order to determine the organic relations of the creature. The individual animalcules are the little green wart-like bodies or specks which are to be seen on the surface of the globe, and singly resemble Monads. They have the same relation to their globe as the individuals of *Gonium pectorale* hold to their tabular clusters. Each sphere or globe is a hollow cluster, if we may so term it, of many hundreds, or even thousands of these living occupants, and often contain within it other hollow spheres, similar in nature to itself.

The individuals are protected by a gelatinous lorica or mantle (*lacerna*), of the form of a bell, which they are enabled to leave, when full grown. They are connected with their neighbours by from three to six filiform cords or tubes. The mouth is situated at

the base of the double proboscis, before mentioned, and indicated by a bright spot. The eye, which is placed near the mouth, implies the existence of a sensitive system. Dujardin has been unable to detect the double proboscis, and the connecting cords as described by Ehrenberg, and consequently admits the existence of only one flagelliform filament.

VOLVOX *globator* (M). *The globe Animalcules.*—The creatures which form these clusters are extremely minute. Each cluster is of nearly a spherical form, and will often contain within its younger clusters, of a green colour, and smooth or even surface. When blue or red colouring matter is mixed with the water, strong currents may be observed under the microscope around each globe, which, when in motion, always proceeds with the same part foremost.

Fig. 55 represents a large globe with eight smaller ones (termed by Ehrenberg, sisters) within it; each of them has a bright spot, which is considered as an opening for the admission of water into the interior.

Fig. 56 represents a section or piece of a globe, magnified 500 diameters; it exhibits five single animalcules and a small cluster of six young ones. They are attached to the lorica, and connected together by five thread-like bands. Each creature has a double proboscis and the red eye.

Fig. 57 represents a single animalcule, separated from its lorica, and magnified 2000 diameters. Found in shallow pools of clear water, in spring and summer, at Hampstead.

The largest globes measure 1-30th of an inch in diameter; the smallest free swimming ones 1-360th to 1-240th. Size of a single animalcule, 1-3500th.

M. Laurent describes two kinds of contained reproductive bodies in this species, the one green and provided with vibratile cilia, the other smaller, consisting of a transparent envelope (shell) which contains a thick and red globular substance. The former he considers to be gemmules, the latter oviform bodies, or ova; which, however, he has not yet seen undergo development. (Institutes de la société Philomatique, de Paris, 1848.)

Ehrenberg notified the peculiar occurrence of living *Rotatoria* within the globes of the *Volvox globator*. Mr. John Williams has

communicated (Trans. Microscopic Soc. vol. iii., 1851), an interesting observation, confirming Ehrenberg's account.

Within the cavity of a large specimen of this species, evidencing its usual vitality, and the ciliary movements on its surface, he noticed a very active *Rotifer*, which he believes to have been the *Notommata parasitica*, and which was subsequently accompanied by another of the same species, but smaller. He adds, "by the most careful examination, no opening could be perceived by which they could have been introduced, neither did there appear to have been any viscera by which their motions might be impeded, as they swam about as freely as fish in a glass-globe, to which, indeed, they bore no faint resemblance."

VOLVOX *aureus.*—Is of a green colour, and nearly globular. The large clusters are in the form of a sphere, and the smaller ones within them of a golden colour, and smooth surface. Found in rain water standing on turf. Diameter of globe 1-36th.

V. *stellatus.*—Is small, of an angular form, and green colour. The clusters are subglobose, sometimes oblong, and contain other globes within them, of a green colour, and having their surfaces tuberculated or stellated. Diameter of globe 1-30th.

Ehrenberg communicated a paper by Werneck, on the Infusoria, to the Royal Academy of Berlin, and an abstract appeared in the monthly report of that society, in which very brief characters of several new genera, both of *Polygastrica*, and of *Rotatoria* are given—two of which are to be inserted in this family *Volvocina*, as allied to the *Pandorina.*—The first genus is called

CALIA.—Monads imbedded in a gelatinous mass, affixed to plants, and not swimming freely about. Two species are known, the (characters not given.)

The second genus bears the name of STEPHANOMA.—*Pandorina* with a single circular series of animalcules, individual corpuscles dividing after the manner of *Gonium*. One species observed—a genus of a peculiar form exhibiting a circlet of spherules, connected as a wreath. (Monatsbericht der Konigl Preuss. Akademie der Wissens. Chaften Zu Berlin. November 1841, p. 377.)

Family.—VIBRIONIA.

The animalcules of this family are distinctly or apparently polygastric, but without a true alimentary canal, and, like the *Monadina*, are incapable of changing the form of their body. They have neither appendages or shell-like covering. They are associated or linked together in thread-like chains, formed by their imperfect transverse self-division. Considering how much we know of the organization of the family *Monadina*, we are comparatively far behind in information respecting the *Vibrionia*, and were it not that the cause of our ignorance is manifestly attributable to the exceeding minuteness of the individual animalcules, we might be justified in imagining their structure to be more simple than in all probability it really is. The filiform and very delicate threads in which they occur, are not, as we have said, separate animalcules, but chain-like clusters, whose almost imperceptible links are themselves (at first) single creatures. The reasons to be assigned for arriving at this conclusion, are, that the clusters or chains have never any determinate length, or number of members forming them, and that they are sometimes so short as to be made up of not more than two or three individuals, and only distinguishable from *Monas termo* and *M. crepusculum* by their mode of union, and peculiar, though not easily characterized movements. Hence all their organic relationships are to be sought for in these minute portions of the chain. To discover these is a task not to be fully accomplished, even with the greatest assiduity, coupled with the most effective optical means which we at present possess. The traces of organization in the members of this family are so few, and those so indefinite, that a question might arise whether or not they are to be considered as belonging to the animal portion of the creation. The answer to this is, that they possess a very powerful writhing, and evidently voluntary form of locomotion; and in one genus (*Bacterium*), a single vibratory proboscis is present as the organ of motion. In it the individual forms are strung more slightly together, the filiform cluster not being able to exert the writhing movement seen in the true *Vibriones*, a direct movement in swimming being alone

practicable. In *Spirillum* the constrictions or articulations are oblique, so that increase in length by division engenders a spiral chain.

The animals of this family "are (says Dujardin,) the first Infusoria which present themselves in all infusions, and those which from their extreme smallness and the imperfection of our means of observation must be considered the most simple; . . . . . and it is only their more or less active movements which lead to their being regarded as animals. I have been sometimes induced to believe that a flagelliform filament, analagous to that of Monads, or rather a spiral undulating one, exists; causing the peculiar mode of locomotion. Is the *Bacterium triloculare*, described by Ehrenberg as having a proboscis a true *Vibrio ?*

All that can be with certainty predicated respecting their organization is that they are contractile, and propagate by spontaneous fission, often imperfect, and hence giving rise to a greater or less increase in length.

The *Vibrionia* are developed with extreme rapidity in all liquids containing changed or decomposed organic substances.

Wagner and Leuckhart, speaking of the sort of motion in cylindrical-shaped spermatozoa, make this general remark, "They are principally limited to a bow-shaped curvature, similar to the motion of the *Vibrionia* which, like the *Monadina,* belong to the vegetable kingdom, and may undergo a further development into fibrous fungi. *(Cyclopædia Anatomy Art. Semen.* p. 503.*)*

Dr. Burnett, of New York, has written a paper to prove that the *Vibrionia* are plants. He says the only assignable reason for considering them animals is their supposed voluntary motion; a supposition to which he is opposed. As evidence of their plant-nature, he adduces the fact of their branching, like Algæ; an occurrence particularly observable in *Spirillum.* He believes the smaller are only the younger forms of the larger species; and that they propagate by gemmation, and not by fission only, as Ehrenberg states.

Concerning the so-called voluntary motion of the *Vibrionia,* Dr. Burnett remarks: "It is because the motions have a kind of directive character that they have been called *voluntary;* a condition necessarily implying a direct act of perception on the part of the form

moved, and one which at once strikes us as untenable. Such motions again are partaken in by spermatozoa and vegetable cells, and cannot be adduced as signs of animality. I know nothing more confirmatory of this than the behaviour of these forms when subjected to certain re-agents." Dr. B. then assumes that beings endowed "with animality, or a separate individual entity, yield more or less to the influence of electrical and other agents, which appear to act without any disorganizing process." He next states that he found "electrical shocks sufficient to kill small animals, had no effect on their (*Vibrionia*) movements. But the application of acids, or other agents acting on the cell-structure, soon caused them to cease." Viewing them as Algeous plants throws light on several common phenomena. One in particular is, that the *Vibrionia* should almost invariably be found in infusions and liquids that contain other algæ, and especially the common *Forula*. For I do not remember ever to have seen the *Forula* without *Vibrionia*."—(*Proceedings of the American Association for the Advancement of Science*, 1850.)

This family is distributed by Ehrenberg as follows:—

Articulated threads (clusters). Straight, the divisions being rectangular and transverse	Inflexible		Bacterium.
	Flexible, like a snake		Vibrio.
Articulated threads spirally twisted (like a bell-spring or cork-screw) the transverse divisions being oblique	Flexible		Spirochoeta.
	Inflexible	with a cylindrically extended spiral form	Spirillum.
		with a disc-like compressed spiral form	Spirodiscus.

On this subdivision of the family *Vibrionia* into genera and species, Dr. Burnett has the following observations: "when we come to organisms as minute as these, the distinguishing characteristics of genera and species become too obscure and equivocal to have much value, and the best microscopists have arrived at the conclusion, that such distinctions are too refined, and will not bear the test of experience.

"The genus *Vibrio*—the simplest, I regard as the first appearance of the young Algæ, existing then as the smallest cells, arranged in linear series. The genera *Spirillum* and *Bacterium*, composed of

larger forms, and of a more fine and solid structure, represent the more advanced forms, and as all Algæ, as they advance in size, tend to consolidate into mycodermous forms, losing much of their primitive cell-structure, so these two genera appear to have lost their old beaded type. As for the two remaining genera, *Spirochoeta* and *Spirodiscus*, but little is positively known. They scarcely appear to belong to the other forms of this family, and as Ehrenberg himself has expressed a doubt upon the subject, one may as well omit a further notice. Therefore, in a structural point of view, the species of this family seem to be only Algæ at different stages of growth."

Genus Bacterium. *The jointed-wand Animalcules* are distinguished by being connected together in a thread-like chain, of an inflexible nature, and by propagating by transverse self-division.

The three species known to us are colourless, and extremely minute. Ehrenberg remarks, "that only one of the species has been satisfactorily determined, and that their organic relations are altogether so occult, that our judgment respecting them must unavoidably be left in a fluctuating state." In B. *triloculare*, organization is discoverable to the extent of a vibratory proboscis, a granulated mass within the body of the creature, and a faculty of spontaneous division. The only animal endowment common to all the species is an active and voluntary power of locomotion.

A magnifying power below 500 times linear will not exhibit the divisions or transverse lines displaying the individuals or links of which the wand-like cluster is composed. I have generally met with *Bacterium* around decomposed vegetable matter, on the surface of water containing chara, &c.

B. *triloculare*. Chain consists of from two to five animalcules, of an oval form, developed in short cylinders, generally about three times as long as their diameter, and marked with transverse lines. Ehrenberg has observed not more than five links together nor less than two, a single animalcule never having fallen under his notice. By throwing a little colouring matter into the water, an evident vibration may be perceived in it, near the anterior portion of the animalcule; and upon a very close inspection, a simple filiform, though short proboscis, is seen, which, in the larger specimens, is one-third the length of the body, and in the smaller, one half. The

motion of this creature is tremulous, or slowly revolving upon its longitudinal axis. Found in the water of bogs. Length of cluster, 1-4800th to 1-2304th ; ditto of link, or single animalcule, 1-11520th. Group 58 represents several of them; two towards the right are magnified 1000, the others 290 diameters.

BACTERIUM *enchelys*. Chain composed of somewhat indistinct animalcules, of an oval form, developed in smaller cylinders than the preceding, transverse lines faintly marked, colourless. Found in river water. Length of cluster, 1-2880th.

B. *punctum*. Chain composed of indistinct animalcules colourless, approaching to a globular form, much smaller than the preceding species, and developed in cylinders, transverse lines faintly marked. Found in water wherein bread has been steeped. Length of cluster, 1-4032.

The following species is added by Dujardin:

B. *catenula*. (D.) Filiform, cylindrical. Length of individuals, 1-8600th to 1-6500th, 3, 4, or 5 are united together, forming a chain 1-1300th in length.

Genus VIBRIO. *The trembling Animalcules.*—This genus is characterised by the animalcules being connected together in filiform chains, of a flexible nature, resembling the body of a snake. These chains, as already remarked, are produced through incomplete self-division. The difficulty of ascertaining the internal organization of this genus has not, as yet, been surmounted, although it is fair to presume that there is nothing of a tubular character, or intestinal canal, running along within their filiform bodies, similar to that of the vinegar eels, or it would most probably have been demonstrated by the aid of coloured food; for a *line* is much more easily distinguished than a *point*. Ehrenberg supposes, that each link in the chain is a closed, round, Monad-like body, having a nutritive apparatus of a polygastric description.

V. *lineola* (*Bacterium termo, Duj.*)—Cluster, a minute cylindrical and slightly flexible wand, rounded at both ends, and made up of bodies somewhat indistinct, but of nearly globular form, and colourless. Commonly found in vegetable infusions, especially round the stalks of flowers in glasses Length of wand, from 1-3600th to 1-200th. Thickness 1-3600th.

Vibrio *tremulans.* Wand short; stouter, yet more flexible, than the preceding; articulations of an oblong form, but not distinct,. Found in water emitting a disagreeable odour. Length of wand, 1-3600th.

V. *subtilis.* Wand slender and elongated; colourless; articulations distinct; motion slightly vibrating, without varying the direct position of the articulations. Length 1-450th. Thickness 1-24000th.

V. *rugula* (*Vibrio regula,* M.) Wand elongated, and stouter than the preceding; articulations distinct, and colourless; motion brisk and serpentine; common in infusions. Length 1-580th. Thickness 1-12000th.

V. *prolifer.* Wand short, stout, and colourless; articulations distinct. Motion slow and tortuous. Found in infusions where mildew is present. Length 1-1100th.

V. *bacillus,* (M.) Wand stout, elongated, and transparent; articulations sometimes distinct, at others, only so when taken from the water and dried; motion serpentine; form straight when quiescent. Group 59, represents three wand-like clusters. Found in vegetable infusions in fetid water. Length 1-200th. Thickness 1-17200th.

V. *synxanthus.* Wands (Bacilli) very fine and short, rather flexuose, rarely, if more than five segments (individuals) yellow and minute. Size of each animalcule 1-70,000th to 1-52000th. Found in decomposing cow's-milk producing a yellow tint.

V. *syncyanus.* Wands very slender and short, somewhat flexuose, of seldom more than five segments, very small, and of a blue colour. Size 1-78,000th to 1-52,000th. Also found in cow's-milk, and producing a decided blue shade.

The following species are from Dujardin's work:—

V. *serpens* (M.) Body very long, filiform, undulating, generally pursuing a rectilinear course, with from ten to fifteen bends in its length. Length 1-1050th.

V. *ambiguus.* Under this name, Dujardin describes a vibrio with stiff filiform joints like those of V. *bacillus,* but much larger. Four or five, or even more, were articulated together; owing to the large dimensions, each joint could be seen composed of a resistant tube, in which a glutinous substance was collected more or less closely. Moreover, a bifurcation at the extremity of a joint was sometimes seen to occur, giving rise to two series, more or less extended.

Such observations tend to render the animality, not only of this vibrio doubtful, but also of the similar but smaller V. *Bacillus* a matter of uncertainty.

Genus Spirochoeta. *The twisting Animalcules.*—This genus is characterized by its members being developed in filiform and flexible chains, of a spiral description, lengthening by the imperfect or incomplete mode of self-division. The details of their organization are at present unknown to us. Dujardin does not admit this as a genus distinguishable from *Spirillum.*

S. *plicatilis* (V. *serpens,* M.) Chain constituted of very delicate bodies, of nearly globular shape, connected together in a long filiform spiral, having numerous and closely arranged coils; colourless. Group 62 shows three clusters. Found at Tilbury Fort. Length of chain 1-170th to 1-440th. Thickness 1-12000th.

Genus Spirillum. *The cylinder spiral Animalcules.*—This genus is characterized by its members developing themselves in tortuous chains, or inflexible and cylindrical spirals. These are elongated in the same manner as before described, by the incomplete self-division of the creatures, which takes place in an oblique direction. Their brisk, energetic, and voluntary motion, and the increase of the chain by division, are the only animal properties which have been hitherto observed as characterizing the creatures.

S. *tenue.* Spiral consists of three or four coils, constituted of very slender, slightly bent, and colourless fibres; articulations distinct. Found in vegetable infusions. Length about 1-900th. Thickness 1-1200th.

S. *undula* (V. *undula* M.) Spiral consists of one and half turns; fibres short, stout, and much bent; articulations distinct; colourless; when dry, the articulations are more distinct. Ehrenberg remarks, that the form of this species is like a bow; and Müller, that it resembles the letter V. Fig. 61 represents a group magnified 800 diameters; the dotted lines indicates the impression left on the eye when the creature is in motion. Found in stagnant water having a mildew scent. Length about 1-1500th. Thickness 1-20,000th.

S. *volutans* (*Vibrio spirillum,* M.) Consists of three, four, or more coils; fibres very tortuous, long, and stout; articulations distinct;

colourless. Found in vegetable infusions. Length of spiral 1-2200th to 1-500th. Thickness 1-14400th.

This creature strongly resembles the minute Algæ discovered by Mr. Thompson, as producing the various colours which the Ballydrian Lake assumes, and which he has described under the name of *Anabaina spiralis*, in vol. v. of the *Ann. Nat. Hist.*; his figures resemble group 61. The genus is characterized as consisting of an extremely minute moniliform thread, of a rich green colour, and regularly spiral, like a corkscrew; globules of equal size throughout." In decomposing, it is at first blue and then ferruginous; each globule appeared to consist of a number of granules enveloped in a hyaline membrane. Length of a single coil about 1-200th

S. *bryozoon*. Coils consist of a thick body, with a delicate wavy hair-like proboscis. These creatures, found in the reproductive organs of plants, are called by their discoverer, Dr. Unger, of Gratz, spermatic animalcules. That distinguished botanist has described them in detail in the *Regensburger Botan. Fictung. Flora.* 1834; and also in the 18th vol. of the *Nova Acta Naturæ cur Bonn*, 1838. As a condensed view of this subject is given by Dr. Meyen in the *Jahresbericht* (a work, the like of which England does not possess), for 1838, I shall here insert the translation I have had made, with the drawings Dr. Unger kindly sent me for this work.

"The spermatic animalcules in Sphagnum consist, according to the earlier observations of Unger, of a thick body, and a thin filiform tail; in motion, this tail being anterior, he holds it analogous to the proboscis of many of the Infusoria. No true active motion of the body itself has been observed by Unger; but he distinguishes between the mere locomotive and the rotatory movements of the whole animalcule. The simplest motion takes place in a spiral direction; and, if the proboscis is contracted, the movement is simply rotatory. During locomotion of the creature, which proceeds in a spiral manner, Unger saw from one to three revolutions of the body in a second; and during rotation, he noticed the point of the proboscis to be in a continual state of tremor. Unger endeavours to show that the spermatic animalcules of the mosses are analogous to the spermatic animalcules of animal organisms, although we find certain things in the former not seen in the latter, and which may somewhat embarrass

their classification, the chief of which are the steadiness of the spiral direction of the proboscis, and their manner of movement. Lately, Unger has found spermatic animalcules in the antheridia of *Polytrichum juniperinum*, P. *commune*, P. *urnigerum*, and P. *alpestre*, as well as in *Funaria hygrometrica*, *Bryum cuspidatum*, and B. *punctatum*, &c., &c. In *Polytrichum commune*, the animalcules are found in very small hexahedral cells with rounded corners. Generally, whilst in the cells they are motionless; in some, however, a tremulous motion of the thin proboscis, and in others, again, a rotatory motion, interrupted at intervals, was seen. The diameter of the delicate proboscis is 0.004th of an inch. In a few animalcules, isolated from their cells, a trembling oscillating motion of the proboscis was seen."

To these particulars, I may add a remark of Dr. Unger, quoted in the *Ann. des Sciences Nat.*, which induced me to introduce the species:—

"The doubts," says Unger, "which remain concerning some of the organs of the animalcules of mosses, further increase the incertitude as to their situation in the scale of beings. From all circumstances, I am inclined to place them in the genus *Spirillum* of Ehrenberg, and to describe them under the name of *Spirillum bryozoon*."

On mentioning these particulars to Mr. Varley, he referred me to his article on Chara, in the 50th vol. *Trans. Soc. Arts*, from which is extracted the following:—

"From these cells" (in the globule in the axil of the Chara) "grow out numerous clusters of long vessels, possessing the most extraordinary features yet observed. When these are first protruded from the globule, if not quite mature enough, their appearance is like dense or strongly-marked ringed vessels, the divisions of which, or their contents, soon begin to appear irregular. * * * After a while, these curls within the divisions become agitated; some shake, or vibrate about; others revolve in their confined places, and many come out, thus showing that they are spirals of two or three curls; these with an agitated motion swim about * * * Now the field of view appears filled with life; great numbers of these spirals are seen agitated and moving in all directions; they all have a directile

force, one end going foremost, and never the other: many stray a great way out of the field: these, by getting clear of each other, are the best to observe; they do not quite keep their form as a stiff spiral, but their foremost end seems to lash about, and to many are seen attached almost invisible but very long fibres. These fibres were in quick undulations, which ran in waves from the spiral to their farthest end. It appears that these fibres cause many of the spirals to entangle together, and thus bring them sooner to a state of rest; therefore, the separate ones were best to observe."

The most recent observations on these creatures, found in the anthers of the *Chara vulgaris* and *hispida*, are by M. Thuret, given to the *Annal. des Sciences*, a valuable translation of which will be found in the *Annals of Natural History*, vol. vii., from which I extract the following:—

"The portion of their body most apparent, appeared like a spirally-rolled thread, of three to five curves. They were slightly tinged with green, similar to the nuclei; and like them, turned brown with iodine, their two extremities becoming more or less coloured (according to the quantity of iodine employed) than the rest of the body, thus indicating a difference of nature in these portions. At a little distance behind one extremity proceed two bristles, or tentacula, of excessive tenuity, which the animalcule incessantly agitates with great rapidity. These are probably organs of locomotion, similar to the filiform prolongation, found in the Infusoria without cilia. Indeed, the part thus furnished with tentacula moves foremost, drawing after it the rest of the body, which turns about in the water, but always preserves its turriculate form. The incessant agitation of these tentacula, and their extreme tenuity, rendered it impossible to observe them in the living animal; recourse was therefore had to the evaporation of the water, or to the application of a slight tincture of iodine, when the animalcules ceased, their motions became contracted, and their spiral unrolled, when the tentacula were rendered very distinct, from their brown colour. These tentacula were frequently observed to be soldered together, from one-half to one-third of their length upwards, but others were also noticed to be entirely separated down to their bases. A swelling

similar to that in the flexure of the body was perceived in their curves.

"Ammonia arrested their motions, and contracted the body gradually into a small oval mass, but did not produce the phenomenon of decomposition by solution *(diffluence)*, so remarkable in the Infusoria. A very weak solution of hydrochloric acid in water violently contracted them into a shapeless mass."

In Plate XII., fig. 519, 520, and 521, represent the spermatozoa found in *Polytrichum commune,* the first figure exhibiting them enclosed in the cellules, and the others swimming freely. Figures 522 to 524, are taken from *Marchantia polymorpha.* Figure 525 is from *Sphagnum capillifolium.* All the above are represented magnified 1000 diameters. Figures 526 to 528 are from the *Chara vulgaris,* and figures 529 to 531 from *Jungermannia pinguis,* as figured in Meyen's work, entitled *Neues System der Pflanzen.*

On this subject of vegetable spermatozoa, Schleiden, in his recent work on the "Principles of Botany," remarks, "The doctrine of vegetable spermatozoa is now I hope gradually dying away. The granules (generally starch), taken from spermatozoa, have indeed lost their life in Fritsche's tincture of iodine, since their evidently, purely, physical, molecular movement remained undestroyed.

" . . . . Fritsche has completely settled the matter, and every unprejudiced observer may convince himself with ease, of the completely untenable nature of the wonders formerly spun out, especially by Meyen. The confirmatory observations of Nägeli on this point are also of great value."

Again, he says, "as to the mechanism of the motion, we know just as little as we do of that of the moving cilia; of the cause of motion, of the motive power, just as much as that of the contraction of the primitive muscular fibre, of the motion of animal spermatic filaments, and of the vibratile cilia on animal and vegetable cells; that is to say, absolutely nothing."

Further, in reference to the motion of the so-called spermatozoa, Schleiden observes—"There can be no question as to its not being a vital phenomenon, because the motions continue even in the alcoholic tincture of iodine (an absolute poison for all vegetable and animal

life), of which one may readily convince himself, and which Tritsche has, with his well known accuracy, shown to be the case in a great number of plants." (See Dr. Lancaster's translation, p. 99 and 359.) This assertion of Schleiden, that tincture of iodine is an absolute poison for all animal and vegetable life, must be received with reserve, since animalcular life has been known to exist in agents, such as strong acids, and mineral poisons, which, *a priori* would appear quite as inimical to it as tincture of iodine; and even minute animals —the *acari*, of far higher organization than the polygastrica, have been stated to preserve life in strong acetic acid.

Before dismissing this subject, it may be useful to append some observations made by Wagner and Leuckhart, in their elaborate and original article before quoted.

Having remarked that up to the most recent period, the so-named spermatozoa of animals have been considered as independent animal organisms, or parasitical animals, and classified among the Infusoria, the authors proceed to say that such assumption is perfectly irreconcileable with our present knowledge of these bodies, based as it is, principally upon the discoveries of R. Wagner, Von Siebold and Kölliker. With our present means of scientific diagnosis it can be proved that the formations in question are mere elementary constituents of the animal organization like the ova; constituents equally as necessary for the spermatic fluid as the blood globules are for the blood. The remarkable phenomena of the life of spermatozoa are quite analagous to those phenomena of motion, observable not only in animal formations, but also in vegetable structures, as, for instance, in the spores of algæ, and of the lower species of fungi, in the so-termed *vibriones* which grow out into the fibres of the conferva called *Hygrocrocis*."

Again, "an unprejudiced observation will prove that the spermatozoa are every where void of a special organization, and consist of an uniform homogenous substance, which exhibits, when examined by the microscope, a yellow amber-like glitter. The opinion of an internal organization of the developed animal elements was not a little supported by the various remarkable phenomena of motion which were frequently perceived in them. In former times, when people had no idea of the existence and extent of the so-called auto-

matic phenomena of motions which take place without the intervention or influence of the nervous system, when nothing was known of the motion, very similar to a voluntary one which exists even in plants; this movement was certainly calculated to place the independent animal nature of the spermatozoa beyond a doubt. But it is different now. We know that motion is not an exclusive attribute of animals, and that an inference respecting the animal nature of the formations in question, however similar the motion observed in them may be to that of animal organizations, is a very unsafe and venturesome one.

We know that certain elementary constituents, animal as well as vegetable, possess a power of movement, and that they retain it for some time after having been separated from the organisms to which they belonged. We only need here remind our readers of the so-called ciliated epithelium, the several cells of which swim about in the fluid surrounding them, and which, when in this state, have not unfrequently, and that even quite recently, been considered as independent animals; how, further, the spores of the algæ possess motion by the aid of a ciliated investment, or of a single or manifold long whip-like fibre, until they eventually become fixed and develope themselves into a new plant. Such spores as these may be found described and illustrated in the well known magnificent work of Ehrenberg, classified as Infusoria, under the groups of *Monadina*, *Volvocina*, &c.

Under such circumstances we may consider ourselves perfectly justified in declaring every attempt to prove the parasitic nature of the spermatozoa by the characteristic of their peculiar motion, as futile and inadmissable."

Genus Spirodiscus.—*The disk-spiral Animalcules* are characterized by developing themselves, through an imperfect self-division taking place in an oblique direction, in elongated chains, or into inflexible spirals, of a disc-like figure. Its organization is so little known that Ehrenberg considers the genus as by no means satisfactorily determined.

S. *fulvus*.—A lenticular spiral, of a yellowish brown colour. Articulation indistinct. Group 62 represents three spirals, magnified 200 diameters. Found amongst conferva. Breadth of spiral 1-1200th.

Family—CLOSTERINA.

The animalcules of this family are polygastric, or to all appearances so, and destitute of an alimentary canal. Their bodies are unvarying in form, and without any appendages. Like the *Cryptomonadina,* they are enclosed within loricated envelopes, which simultaneously with their bodies, undergo incomplete self-division, so as to form polypi-shaped clusters, of a wand, thread, or fusiform figure. Each individual is furnished with a papilla, or sort of nipple, which protrudes, but very slightly, through an aperture in the shell, and serves as an organ of locomotion.

The envelope, or lorica, investing these creatures, is of the form of a little pitcher *(urceolus),* and either of a yellowish colour, or colourless. In many of the species it is open at both ends. The animalcule itself is a very delicate mucous body, clear as crystal, and often contains within it vesicles and green granules, which latter are most probably ova. The locomotive organs appear to be very short, slender, and conical-shaped papillæ or nipples, of a transparent hue, placed just within the opening of the lorica, and but very slightly protuding from it. The small vesicles observable among the green ova are, according to Ehrenberg, belong to the polygastric apparatus.

As several eminent botanists have considered the various species included in this family, and the family *Bacillaria,* as belonging to the vegetable, and not to the animal kingdom, I have transferred the generic and specific descriptions to Section 1 of the family *Bacillaria.*

It should be borne in mind, in treating of this matter, that the descriptive characters of the *Closterina,* and the illustrative drawings of them, will not be in the least reduced in value or interest, whether these organisms are considered as forming a portion of the animal or vegetable creation.

To the microscopist the members of this family possess much interest, arising from the circulation of the particles within the shell near the ends, and also along the sides. For these observations an

amplifying power of 400 diameters, is required; but even a single lens of that power will shew it.

I may remark here that many observers with the microscope, and even acute naturalists, have been unable to see the circulation in these creatures, and I have for many years past received queries on this subject; even Mr. Ralfs, in his beautiful work on *British Desmidieæ,* had not seen it until shewn by Mr. Brawerbank. This is the more remarkable, as a good single equi convex lens will exhibit it. The difficulty appears to me to arise from the want of proper adjustment of the focus. The best method is carefully to adjust the focus of the microscope for a distinct vision of the outer shell, then to bring the object a little within the focus and the circulation, will be seen; the vision of the shell being indistinct. For observations on the circulation, stops or diaphragms, under the stage, may often be employed with advantage; a large angle of aperture not being essential. The circulation in the *Closterina* resembles the diffused circulation in the aquatic lavæ of insects, or that seen at the joints of the legs of spiders.

This phenomenon is sometimes compared with the *cyclosis* in the *Chara* and other plants.

Ehrenberg gives the following reasons for placing the *Closterina* in the animal kingdom:—First, they exert a voluntary motion, as shewn first by Corti. Secondly, they have apertures at their extremities, as noticed by himself. Thirdly, they have projecting organs near these apertures, perpetually in motion. Fourthly, they increase and multiply by a transverse self-division, as observed by Müller. These four endowments Ehrenberg considers as being abundantly sufficient to determine the real nature of the *Closterina,* inasmuch as whereever voluntary motion, an aperture or mouth (feet), and spontaneous division exist, you may conclude at once, *without waiting to see the creature eat,* that the supposed plant is indeed an animal.

Since the above was written, some interesting observations have appeared in No. xxxiii. of the *Annals of Natural History,* by Mr. Dalrymple, from which I select the following; my intention in this work being not to confine it to my own views, but also to record those of others, believing that, by so doing, I shall best serve the public, and advance this science.

Mr. D. describes the *Closterium* as consisting of " a green gelatinous

and granular body, invested by a highly elastic and contractile membrane, which is attached by variable points to a hard siliceous shell." This lorica, Mr. C. Varley states, will resist even the action of boiling nitric acid. "The form of *Closterium* is spindle-shaped or crescentic, the shell consisting of two horns, tapering off more or less to the extremities, and united at the central transverse line, constituting a perfectly symmetrical exterior. At the extremity of each horn is an opening in the shell, which, however, is closed within by the membranous envelope—wanting, however, in some specimens. Within the shell, and at the extremity of the green body is a transparent chamber, containing a variable number of active molecules, measuring from the 20,000th to the 40,000th of an inch; these molecules, or transparent spheroids, occasionally escape from this chamber, and circulate vaguely and irregularly between the periphery of the gelatinous body and the shell. Further, the parieties of this chamber have a contractile power." The author denied the existence of any papillae or proboscides at this part, as well as the supposition of Ehrenberg, that these moving molecules constitute the bases of such papillae. He also denied the statement of the same distinguished observer, that if colouring matter was mixed with the water in which the *Closterium* resides, any motion was communicated to the particles of such colouring matter by the supposed papillae, or by the active molecules within the terminal cells. A circulation of the fluids within the shell was observed, independent of the vague movements of the active molecules; this was regular, passing in two opposite currents, one along the side of the shell, and the other along the periphery of the gelatinous body. When the shell and body of the *Closterium* was broken by pressure, the green gelatinous matter was forcibly ejected by the contraction of the membranous envelope.

"The action of the iodine upon the specimens was very remarkable: 1st, it did not, as reported by Meyen, stain the green body violet or purple, but orange brown: 2nd, it produced violent contraction of the investing membrane of the body, whereby the green matter was often forcibly expelled from the shell at the transverse division; it instantly annihilated the motion of the molecules in the terminal sacs, and the sacs themselves became so distended with fluid as to

burst, and allow the molecules to escape".—The following are Mr. D.'s reasons for classing the *Closterina* with animals:—

"1st. That while *Closterium* has a circulation of molecules greatly resembling that of plants, it has also a definite organ, unknown in the vegetable world, in which the active molecules appear to enjoy an independent motion, and the parieties of which appear capable of contracting upon its contents.

"2ndly. That the green gelatinous body is contained in a membranous envelope, which, while it is elastic, contracts also upon the action of certain re-agents, whose effects cannot be considered purely chemical.

"3rdly. The comparison of the supposed ova with the cytoblasts and cells of plants precludes the possibility of our considering them as the latter, while the appearance of a vitelline nucleus, transparent but molecular fluid, a chorion or shell, determines them as animal ova. It was shown to be impossible that these eggs had been deposited in the empty shell by other infusoria, or that they were the produce of some entozoon.

"4thly. That while it was impossible to determine whether the vague motions of Closterium were voluntary or not, yet the idea the author had formed of a suctorial apparatus forbad his classing them with plants.

"Lastly, in no instance had the action of iodine produced its ordinary effects upon starch or vegetable matter, by colouring it violet or blue, although Meyen asserts it did in his trials."

The author therefore concluded that Closterium must still be retained as an infusory animal, although it is more than doubtful whether it ought to rank with the polygastric families.

Family.—ASTASIAEA.

This family is characterized by its members being polygastric, and deficient of the true alimentary canal, appendages, and lorica. They are furnished with a single aperture, and often with a tail, and have the power of changing their form at pleasure. They afford as beautiful living bjects for the microscope as any that have ever fallen

under my observation. The tail may be considered as an organ of locomotion, and the single proboscis of three of the genera, and the double proboscis of one other genus, have a like office. It is probable that probocides exist also in the genus *Colacium*, although they have not been determined; but in the *Distigma* there is hardly a doubt of their absence. The vesicular cells have been supposed to form a portion of the nutritive apparatus, although it is not satisfactorily demonstrated by the application of coloured food. Ehrenberg has, nevertheless, noticed some manifestations of an artificial action having been produced, as he observed green and red cells in the *Euglena viridis*. Three genera in this family exhibit signs of the hermaphrodite condition, whilst the other three, *Astasia*, *Distigma*, and *Colacium*, have only one form of reproductive apparatus, namely ova. In the *Euglena* there may be seen, in addition to the green ova and seminal glands, a contractile vesicle of a seminal description, and the large red visual points in five of the genera affords evident tokens of a system of sensation. What, however, may be deemed most worthy of remark in this family is, that in the species, *Euglena longicauda* and *amblyophis* we have the first indications of the presence of nervous matter that is to be found in the polygastric Infusoria, in the form of a white glandular knot, situated below the eye.

The following table is descriptive of the genera of this family:—

Eye wanting					Astasia.
Eyes present	With one eye	free	with one proboscis	tail wanting	Amblyophis.
				tail present	Euglena.
			with two proboscides		Chlorogonium.
		attached by a pedicle			Colacium.
	With two eyes				Distigma.

The family *Euglenæ* (*Eugleniens*) of Dujardin, in a great measure corresponds with that of *Astasiæa*, of Ehrenberg, the first named naturalist preferring the term *Euglenæ*, on account of the resemblance of Ehrenberg's name to that of a family of Crustaceans, viz., the *Astaciæ*.

Dujardin looks upon the so called eyes as insufficient to afford

generic characters, which he would derive from the nature or apparent structure of the integument, and the number or mode of insertion of the filaments. He thus forms a genus *Polyselmis,* characterized by its many filaments; two genera *Zygoselmis* and *Heteronema,* by a pair of filaments, in the former of equal, in the latter of unequal size. The remaining *Euglenece* have but a single filament, and can be but uncertainly defined; such are the *Euglenece* mostly coloured, and having a red eye speck, and with a tail; the *Astasia* without colour and tail, but with a filament flexible throughout, and springing abruptly from a notch in the anterior extremity; and the *Peranema* differing from the *Astasia,* only in having a filament rigid at the base, and apparently but a continuation of the tapering anterior extremity of the animalcule. The two last genera, are, however but provisional.

Dujardin differs entirely from Ehrenberg, in his interpretation of the internal organization of the *Astasia* or *Euglenians;* neither stomachs, sexual system, ova, or nerve matter are recognized by the former.

The members of this family mostly inhabit stagnant ponds. I have always found them at the surface. They sometimes tinge the water with their own colour. When swimming they present an elongated form, but when fixed, often appear as round globules. They seem capable of progressing, by alternately fixing and advancing the head and tail after the manner of a leech; Dujardin doubts the oblique fission of *Chlorogonium.*

It is with certain members of this family that M. Thuret finds so close an affixity—even an apparent identity, to exist with the reproductive spores—Zoospore of the Algæ. "This affinity," he says, is exhibited in colour, form, number and character of the ciliary filaments, in the contents, not excepting the coloured eye-speck, in the mode of self-fission, and also in the power of locomotion. What is still more, both Zoospores and *Astasiœa* tend to the light, disengage a gas, most probably oxygen, and emit a peculiar spermatic odour. However, by continued watching the Zoospores are seen to affix themselves to some body, surrender their seeming animal life, and proceed to germinate, developing a tissue similar to that of the plant which gave them birth. On the other hand, the true *Astasiœa,* if they

attach themselves, it is but for a time, and no appearance of germination ensues. The closest similarity exists in the case of the *Chlamidomonas pulvisculus*, (*Diselmis viridis* Duj.), and in a less degree in the *Euglenæ*. (See Part I., page 46.)

Genus Astasia.—The members of this genus are characterized by their being free (not attached by a pedicle), and being furnished with a long or short tail, but no eyes. *A. pusilla* is the only species in which digestive cells have been clearly seen. Ova are perceptible in *A. haematodes*, and probably exist in the three other species; a locomotive organ in the form of a thread-like proboscis exists in *A. pusilla.*

The immense numbers in which these Infusoria are developed in a few days, and the blood red-colour they impart, have not unfrequently been the cause of considerable alarm and anxiety to persons residing in the vicinity of the waters wherein they are found.

A. *haematodes. The blood-like Astasia.*—Body fusiform, or spindle-shaped, when extended; tail very short, body green at first, afterwards of a blood-red colour. Group 68 represents one creature extended, and another contracted. (Hampstead). Length 1-380th.

A. *flavicans.*—Body extensible, cone-shaped, approaching cylindrical, and rounded at the foremost extremity. Tail very short and blunt; ovaria of a yellowish colour. Found in yellow ditch water. Length about 1-430th.

A. *pusilla.*—Body extensible, cone-shaped, swelling out, and rounded at the fore extremity; tail very short and pointed, colourless. Group 69 represents two of them magnified.

Ehrenberg remarks, they are often so abundant, that thousands, perhaps millions, of these creatures are sometimes contained in the hollow of a watch-glass, and that they rise up and form a stratum on the surface of the water. They might be mistaken for the young of the A. *flavicans* , but that the vesicles within them, which appear to be digestive cells, are larger than those in that species, which is moreover without proboscis. As soon as a little colouring matter was thrown into the water, an evident current was observed near the fore part of the creature; and by this means, in 1833, the thread-like proboscis, which is about half the length of the body, was first perceived. Sometimes the entire creature appeared to glisten. Should this species, upon closer inspection, be found to be ciliated,

it would be rightly placed in *Peridinea*. Length 1-1440th to 1-840th.

Astasia (?) *viridis*. Body extensible, and of an ovate-oblong form, distended a little at the middle; tail very short and pointed; green. Found amongst Conferva. Length 1-1200th to 1-900th.

A. *nivalis*.—Form oval, extremities rounded, rarely pear-shaped, colour deep reddish-brown, motion rapid. Found with *Protococcus nebulosus* in snow (Switzerland). (P. 12, Group 526.) Length 1-1500th.

M. Vogt in his account of the *Astasia nivalis*, describes it as invested with a carapace (lorica), open only at the anterior extremity. This opening is furnished with numerous small cilia, and here, doubtless, the mouth is situated, the indication of which is given by an orange-coloured tint, which is clearer than that of the rest of the animal. "The presence of the lorica together with the cilia, are characters which do not allow this animalcule to be placed with *Astasia*, as Shuttleworth has done: on the contrary, it ought to be placed in the family *Peridinia* (Ehr.); or otherwise be regarded as the type of a new genus, distinguished by the absence of a grove in the lorica, and by the stiff hairs of *Peridinia* being replaced by soft cilia." (On the Animalcules of the Red Snow.—Bibliothèque Univers de Genève.)

A. *acus*.—Body hyaline, of a long fusiform figure, acute at each end, filament the length of the body. Length 1-650th. Berlin.

Dujardin's genus *Astasia*, is defined as colourless, obtuse, or rounded posteriorly, whilst those described by Ehrenberg, are mostly green or red, and provided with a longer or shorter caudal prolongation.

The following species are from Dujardin.

A. *contorta* —Body colourless, semi-transparent, containing pale yellow granules, cylindroid, enlarged at the middle, obtuse at each end, and marked with oblique striæ, giving rise to a twisted appearance. Length 1-450th. Found in sea water.

A. *inflata*.—Body semi-transparent, diaphanous, contractile, ovoid, obliquely, but regularly plaited or striated. Length 1-560th. In sea water.

A. *limpida*.—Body diaphanous, smooth, very variable fusiform, more or less obtuse at each end, cleft anteriorly, and often obliquely

doubled on itself or twisted. Length 1-650th. to 1-520th. In ditch water.

Genus AMBLYOPHIS. *The tail-less eye Astasiæa.*—The characteristics of this genus are, that it is free, possesses an eye and single thread-like proboscis, but is tail-less. The proboscis serves as an organ of locomotion, and is situated at the creature's foremost extremity, which, says Ehrenberg, is cleft, so as to represent a two-lipped mouth ; the upper lip bearing the proboscis, being very readily distinguished. The colour of the animalcule is derived from the closely compressed mass of green granules, which nearly fills the body, and may be regarded as ova. There may be seen also, near the middle of the creature, a large bright globular body, and five wand-like bodies, two of which are situated before, and three behind, the first mentioned one. The whole of these are supposed to be male generative organs. No contractile spermatic vesicle has been observed. Self-division is unknown in these creatures. The sensitive system is more beautifully and clearly developed in this genus than in any other of the Polygastric Infusoria. Towards the anterior part of the body, and just behind the proboscis, where the mass of ova commences, there is a bright red and somewhat lengthened spot (resembling, as to situation and colour, the eye of the wheel Animalcules and Entomastraca), beneath which, in the clear space below, is a mass of matter of a very peculiar description, of a globular form, having the appearance of nervous ganglia, and being most probably connected with the organ of vision.

A. *viridis.*—Body large, elongated, cylindrical, distended or compressed, and abruptly rounded at the posterior extremity; green; head colourless; eye large, bright red. The motion of this creature is dull and serpentine, and by its evolutions might easily be mistaken for the *Euglena spirogyra,* were that creature, like this, tail-less-Group 70 represents three specimens, one full grown, and the others young. Found with *Euglena,* chiefly in the spring. Length 1-210th to 1-140th.

Genus EUGLENA. *The eye Animalcule.*—This beautiful genus of the family *Astasiaea* is characterized by its members being furnished with an eye, a single thread-like proboscis, and tail, and by their being free, that is, not attached by a pedicle. The locomotive pro-

boscis belongs to nine species out of the eleven, and a double appearance of this organ has been observed in the E. *sanguinea,* ascribable, no doubt, to the preparatory condition of the animalcule for self-division.

In *Euglena hyalina,* E. *pleuronectes,* and E. *longicauda,* nutritive cells are generally visible, but in the other species they are obscured by the masses of green ova, which colour their bodies. Certain internal appearances have been recognized, which Ehrenberg supposes to be of a male generative nature. Longitudinal self-division has been observed in E. *acus,* and the preparation for it in E. *sanguinea,* as before mentioned. The red visual point indicates the existence of the sensitive system in this genus, and a nervous ganglion is visible in E. *longicauda,* as in E. *amblyophis.*

The genus *Euglena* of Ehrenberg, says Dujardin, contains some species of a compressed leaf-like form, and quite deficient of contractility, and ought to be placed in the genus *Phacus* of the family *Thecamonadina.*

Respecting the so-called red eye, the French naturalist also remarks that it is far from being a true eye, appearing as it does often like an irregular collection of two, three, or even four granules, sometimes with considerable intervals between them, but this appearance I have observed in several *Entomostracea* when the magnifying power of the microscope is not sufficient.

The *Euglena* are undoubtedly animals, yet their composition is *binary,* and they evolve oxygen, two characteristics of plants. But on the other side, certain mushrooms and other cryplogamous plants, are *tertiary* in composition, having that usual animal element, nitrogen; and they evolve carbonic acid, both characters of animals.

In the 'Miniature Achromatic Microscope' with a magnifying power of 150 diameters, most of the species may be well observed.

E. *sanguinea* (*Cercaria viridis,* M.) Body extensible, of an oblong cylindrical or spindle-shaped form, with the head greatly rounded; the tail is short, conical, and somewhat pointed. Proboscis longer than the body in its extended condition. When young, they are green, but when full grown, are of a blood red colour. The motion of this multiform animalcule is generally slow, and it sometimes revolves upon its longitudinal axis in swimming. Its colour is not

of a fixed character, sometimes being green, at others, a mixture of red and green. This arises, according to Ehrenberg, from the different condition of the ova at different times; the ova conceal beneath them numerous round granular bodies, supposed to be digestive cells. The thread-like proboscis, which is a prolongation of the upper lip, and rather longer than the body, is so delicate, as to require considerable care in investigating it, and being retractile, will often elude observation. A little colouring matter in the water will exhibit this organ in active operation, and it may be distinctly seen in a single animalcule, in a dried state, upon a plate of clear glass. The double appearance of the organ in this species has been before noticed. Ehrenberg conjectures that the miracle in Egypt, recorded by the great lawgiver of the Jews, of turning the water into blood, might have been effected by the agency of these creatures, or by the *Astasia hæmatodes*. Figures 71, 72, and 73, represent the creature in different states. In the first, it appears elongated, and currents in the water are shown near the mouth. In the others, the cilia-formed thread-like proboscis is seen. Found in stagnant water, often in great abundance, on the surface of ponds. Length 1-300th to 1-240th.

Euglena *hyalina*. Body extensible in a spindle-shaped manner, with the head attenuated, blunted at the extremity, and two-lipped; tail short, and somewhat pointed; colour transparent and whitish, rare. Length 1-280th.

E. *deses* (*Enchelys deses*, M.) Body extensible, cylindrical, abruptly rounded at the head, and slightly bi-lipped. Tail very short and pointed; colour green; motion a winding and sluggish creeping, never swimming. Found amongst Lemna. Length 1-240th to 1-760th.

E. *viridis* (*Cercaria viridis*, M.) Body extensible in a spindle-shaped manner, with the head attenuated and short. Tail short, and cone-shaped, not cleft; colour green, excepting the two extremities, which are colourless. The double pointed tail, supposed to have been seen by Leeuwenhoek, Ingenhousz Müller, Schrank, and Nitzsch, does not exist. The colour of the eye is often pale red, when the creature is young, so that it may be easily mistaken for the *Astasia viridis* or *Monas deses*. When dried on glass, the eye seldom retains

its colour more than a week, but the proboscis may be well examined, and preserved in that state. Length 1-240th. Found on the surface of ponds at Hampstead.

Euglena *spirogyra.* Body extensible and cylinder-shaped, very finely striated and granulated. The head is a little truncated, and the hinder part attenuated into a short pointed tail; colour a brownish-green; motion like E. *deses.* Found amongst Conferva and *Bacillaria.* Length 1-240th to 1-120th.

E. *pyrum.* Body obliquely fluted; when distended oval or pear-shaped. The tail generally about the length of the body and pointed; colour green. Group 74 represents two of these creatures magnified 400 diameters. Rarely found with any other species. I have taken them at Hampstead, but not so frequently as the other species. Length 1-1152nd to 1-864th.

E. *pleuronectes* (*Cercaria pleuronectes,* M.) Body compressed, ovato-orbicular, or in the form of an obovate leaf; striated longitudinally; colour green; tail pointed one-third or one-fourth part the length of the body, and colourless. Found in stagnant water. Length 1-1152nd to 1-480th.

E. *longicauda.* Body mostly stiff, compressed, elliptical, and leaf-like; colour green; tail the length of the body, awl-shaped, subulate, and colourless. Within this creature may often be seen a yellowish-green mass of granules or ova. The very delicate vibrating thread-like proboscis represented in figs. 75 and 76 has its origin from the more projecting side of an indentation on the anterior edge of the body, and is about two-thirds its length. This creature has the power of twisting its body into a spiral form, as seen in fig. 75, but not of contracting it. It swims freely, and mostly with a vibratory motion, occasioned by the action of the proboscis. Found in fresh water amongst Conferva and with the *Bacillaria.* Length 1-480th to 1-120th.

E. *triquetra.* Body leaf-shaped, three-sided, oval keeled; colour green; tail shorter than the body, and colourless. See fig. 77. Found amongst Lemna. Length 1-580th.

E. *acus* (*Vibrio acus,* M.) Body slender, spindle-shaped, and straightened in the form of a bodkin; head attenuated, and a little truncated; tail very pointed, body green in the middle, and colour-

less at the extremities. This is one of the most beautiful animalcules I have seen under the microscope; its graceful form when swimming, its bright red eye, the curious forms it assumes when stationary, and its remarkable appearance when undergoing self-division, all combine to render it worthy of observation. Group 78 shows the normal form of this creature; the figure to the right, the same bent and contracted; and the lower, another undergoing longitudinal self-division. Found both in fresh and brackish water. Length 1-570th to 1-210th.

EUGLENA *rostrata*. Body elongated and conical, with the hinder part gradually attenuated into the tail, which is very short. Head slightly bent, like a beak; colour green. Found amongst *Oscillatoria* and *Bacillaria*. Length about 1-500th.

E. *ovum*.—Body ovate green, with a very short hyaline caudal prolongation; and a large double circular gland. Size 1-1560th. Found at Berlin.

E. *geniculata*. (D.)—Body green elongated, cylindrical, flexible, but not very contractile, movement slow, tail tapering, and at an angle with the body, hence the name. Length 1-208th to 1-175th.

This large *Euglena* is remarkable by its elongated form, by its diameter being nearly equal to its length, without the bulging of *E. viridis*, and by its articulated tail.

E. *obscura*, (D.)—Body thick, oblong, distended and obtuse posteriorly; of very variable form, clearer, and of a red tint anteriorly, eye-speck reddish black; filament half as long again as the body. Length 1-870th.

Genus CHLOROGONIUM. *The Astasia with a double proboscis.*—This genus comprises those members of the family *Astasiaea* which are provided with an eye, tail, and double thread-like proboscis; their motion in swimming is free, the creature not being attached by means of a pedicle or foot-stalk. The only known species is of a very beautiful green colour, and has numerous transparent vesicles within it, which are apparently subservient to the purpose of nutrition, although this fact has not been determined by the imbibition of coloured food. A faint, clear, glandular body (the male generative system) is perceptible in the centre of the animalcule, the female being represented by the mass of green ova, which confers the colour

on the creature. The double proboscis is used as an organ of locomotion, and the bright red eye affords the usual evidence of the existence of a system of sensation. Self-division in the transverse direction, somewhat modified, has been observed to take place.

CHLOROGONIUM *euchlorum.*—Body spindle-shaped, very pointed at both extremities; tail short; colour sparkling green. The eye of this animalcule. although distinctly marked, is, nevertheless, so delicate, that it may be easily overlooked; but when the creature is dried upon a plate of very clear glass, both the eye and the double proboscis are readily seen, and may be well preserved as a permanent microscopic object. Group 79 represents six creatures in one cluster, each with its double proboscis; above them is one about to divide into three; and on the right of this are three young animalcules. Found in water-butts, &c.: on ponds it forms the green matter of Priestley. Length 1-110th to 1-280th, exclusive of the tail.

It was in this species that M. Weisse thought he had discovered a form of propagation analagous to that by ova. He observed the contained green matter, with its scattered vesicles, contract in some measure upon itself, exhibit a constriction, indicating a line of division, subsequently followed by the appearance of other constrictions, until the entire contents assumed a nodular form, resembling a bunch of grapes. This grape-bunch mass possessed a certain degree of movement within the enclosing integument, and as the process of development further proceeded, its separate particles or granules also displayed a movement among themselves, increasing in vigour until the outer envelope burst and gave them exit as so many distinct independent beings, moving freely about in the surrounding water.

These young forms so produced, especially in their aggregate state before discharge, resemble *Uvella Bodo*, and M. Weisse thinks *Chlorogonium euchlorum*, and *Glenomorum tingens*, but other stages of their development. From the above observation, that naturalist is led to the conclusion that *Polygastrica* do reproduce, in some sort, by ova, and that some forms described by Ehrenberg as independent genera, are but different phases of development of the same being.

Genus COLACIUM. *The friends? of the Water Flea.*—This genus is characterized by the creatures belonging to it being endowed with a single eye, and attaching themselves to other bodies by means of a

pedicle or foot-stalk, which is single, or ramified by the process of self-division. The usual locomotive proboscis has not been detected in this genus, although, as Ehrenberg remarks, there can be no doubt of its existence, from the currents which are visible in coloured water near the forepart of the body. But these being rather feeble, render it probable that the organ is a single filiform proboscis. The red visual point is indicative of a system of sensation, and the numerous transparent vesicles within the body denote one of nutrition. The creatures are parasitical upon *Entomostraca* and *Rotatoria.*

Chlorogonium (?) *vesiculosum.*—Body of a spindle-shaped oval form, but variable, with the pedicle very short, and seldom ramified; colour, sparkling green, with distinct internal vesicles. Ehrenberg says, "I have again sought in vain for the red eye (May 23, 1835), but cannot be satisfied of its non-existence, as it is undoubtedly present in the other species, and investigation is sometimes unproductive, on account of subordinate circumstances. I have likewise failed in seeing very satisfactorily the vibratory organ, notwithstanding its action is evident enough." Plate 2. f. 80, represents a portion of the back shield of the *Cyclops quadricornis* (see *Microscopic Cabinet,* P. 9), with six of these creatures attached to it; one appears double, longitudinal self-division having just taken place. Found upon *Entomostraceans.* Length 1-860th.

C. *stentorinum.*—Body expansible and variable, somewhat cylindrical in form; its fore part expanded into a cone or funnel-shape process; colour, a beautiful green; vesicles indistinct, pedicle often ramified. Found upon *Entomostraceans* and *Polyarthra trigla.* Length 1-1150th.

Genus Distigma. *The double-eyed Astasia.*—The characteristics of this genus, are, the possession of two eyes, and a freedom of motion. Locomotive organs have not been hitherto discovered, and the presumption is, that they do not exist, as none of the species either swim or produce perceptible currents in coloured water. They have a sort of creeping or crawling movement, much like eels, and can change their forms, after the manner of the *Proteus;* they approximate the *Amœba* in other respects, besides the deficiency of the proboscis. At the fore part of the body may be seen two very delicate

blackish-coloured spots, analagous to the eyes in the species of other tribes. The *Distigma* are sometimes confounded with *Proteus diffluens* of Müller. All the species are exquisite objects for a deep powered microscope, for instance, one magnifying 460 diameters.

DISTIGMA *tenax* (*Proteus*, M.)—Body larger than in either of the other species, proteus-like, at times greatly distended, then as much constricted: eyes rather indistinct; colour transparent yellow. Found about Lemna. Length 1-240th.

D. *proteus* (*Proteus*, M.)—Body smaller than the preceding, proteus-like, sometimes greatly distended, at others constricted, blunted at both extremities; eyes distinct. Group 81 represents these creatures highly magnified. Found amongst conferva. Length 1-580th. to 1-400th.

D. *viride.*—Body smaller than in either of the other species; proteus-like, sometimes greatly distended, at others constricted; filled with green granules; eyes distinct. Length not exceeding 1-570th.

D. *planaria.*—Body small, linear, proteus-like, but less distended or constricted than the preceding, pointed at both extremities; colourless; eyes distinct. Found by Ehrenberg amongst Conferva in the Nile. Length 1-240th.

The following genera and species, are included by Dujardin in this family.

Genus PERANEMA.—Body of variable form, sometimes almost globular, at others distended posteriorly, and drawn out in front, or prolonged into a long tapering filament. Movement forwards, slow, uniform.

The *Peranema* are colourless, but contain in their diaphanous substance, granules and vacuolæ. The lobes they send out in their frequent and remarkable changes of form, are, unlike those of the *Amœba*, covered with an integument. They are found in stagnant marsh water, chiefly on the surface of dead plants.

I suspect Ehrenberg has described a species *(P. protracta)* of this genus, under the name of *Trachelius trichophorus*.

P. *protracta.*—Body oblong, soft, dilated posteriorly, much extended anteriorly. Length 1-838th. to 1-370th.

PERANEMA *globulosa.*—Body nearly globular, more or less extended anteriorly, with oblique plaits on its surface. In the Seine. Length 1-1625th to 1-1300th. (P. 21. f. 13.)

P. *virescens.*—The animalcule so named, occurred in the water of the Seine, was green, semi-fluid, and changed form most rapidly, like an *Amœba.* Length 1-860th. to 1-520th. Requires further examination.

Genus ZYGOSELMIS.—Animal of variable form, swimming by means of two equal flagelliform filaments, constantly in agitation.

Zygoselmis is distinguished from *Diselmis,* by its contractility, and its variability of form.

Z. *nebulosa.*—Body colourless, sometimes globular, at others, top or pear-shaped, with numerous contained granules. Length 1-1300th, with two filaments of equal size and length. (P. 21. f. 12. *a. b.*)

Genus HETERONEMA.—Body of variable form, oblong, irregularly dilated posteriorly, having a fine flagelliform filament, and a second thicker trailing one, acting as a retractor.

This genus, by possessing the two filaments, of different characters and office, approaches the *Heteromita* (137) and *Anisonema* (150); from which, however, it is distinguished by its contractile, obliquely striated integument.

H. *marina.*—Body oblong, irregularly dilated behind, narrower in front, obliquely and closely striated. Length 1-434th. Found in sea water. (P. 21. f. 11.)

Genus POLYSELMIS.—Animal oblong, of variable form, swimming by means of several flagelliform filaments, arising from its anterior extremity.

The single Infusorium (says Dujardin) bearing these characters, resembled an oblong *Euglena,* rounded at each end with an anterior longer moveable filament, surrounded by three or four very fine shorter ones.

P. *viridis.*—Body elongated, rounded at each end, more or less dilated, and folded at the middle; green, with a red eye-speck. Length 1-650th. Found in a glass of marsh water, containing Lemna, and which had been kept several months. (P. 21. f. 7.)

Family.—DINOBRYINA.

The animalcules of this family are distinctly, or to all appearances, polygastric, and furnished with only one aperture to the body; hence, like polypes, they can have no true alimentary canal. They are possessed of a lorica or shell, and have the power at will, of changing their form, but are without appendages. In one species of the genus *Dinobryon* a simple filiform proboscis is present; and in the same genus, a delicate red spot, at the anterior portion of the body, indicates the organ of vision. The nutritive apparatus is obscure and undefined. The lorica is of the form of a little pitcher (*urceolus*), at the bottom of which the very contractile Euglena-like creature is attached. Two genera only are known.

Genus Epipyxis. *The Pedestal Animalcule.*—The characteristics of this genus are mostly of the negative kind; it wants the eye and is attached. The most evident animal character possessed by the species is the funnel-shaped orifice at its foremost extremity. The soft or pulpy body is lodged within a delicate membranous (not siliceous) lorica, which is usually affixed by a pedicle, or foot, to a piece of Conferva.

E. *utriculus.*—Body of a conical pitcher-like form, small, and filled with yellowish granules; attached by a pedicle. Group 82 represents several of these creatures attached to a portion of conferva. Length 1-640th.

Genus Dinobryon.—This genus is distinguished from the preceding one by possessing an eye, and enjoying a freedom of motion. The lorica also is more free from the body of the creature than in *Epipyxis.* Reproduction takes place by gemma or buds, which do not separate from the parent; hence a shrubby, forked, and Monad-like cluster is produced.

D. *sertularia.* Body large, invested with a lorica, slightly excised, and dilated at the mouth, but constricted near the base. Developing in the form of a shrub. (See group 83 and fig. 84.) This animalcule

is not readily seen, by reason of its crystalline lorica, and colourless body: by a patient investigation, however, the little shrubby colony may be perceived rolling along, and advancing in the field of view. Within each lorica a pale yellow animalcule may be noticed, in form somewhat resembling the young of the *Chlorogonium* or *Euglena viridis.* This creature has the power of stretching itself out in a spindle-shaped manner, so as not to protude, however, beyond the mouth of the lorica, and also of contracting itself into a globular form. The red point is observable at the anterior part of the body, and a single thread-like proboscis is thrust forth from out of the shell. Cluster 83 represents a shrubby cluster, containing eight animalcules, and the shells of three which have died. The vibrating proboscides act like so many paddles in the water, and propel the moving mass. Found in bog-water. Length of single animalcule 1-570th; ditto of cluster 1-120th.

Dinobryon (?) *sociale.*—Body small, enveloped in a shell of a simple conical shape, truncated at the mouth. Developed in the form of a shrub. Found in fresh water. Length 1-860th; ditto of cluster 1-280th.

D. *gracile.*—Less branching *(fruticose)*, lorica slightly constricted at the middle, aperture truncated. Size of single animalcule 1-2080th.

Family—AMOEBAEA.

The animalcules of this family are polygastric, with one aperture only to the body, and no alimentary canal or lorica. No other organs of motion are observable than certain appendages or ramifications, consisting of variable pediform processes, which they have the power of putting forth from every part of their gelatinous and contractile bodies, and by which they move from place to place. The organs of nutrition are composed of numerous digestive cells, which are visible in all the species, either in their natural state, or by the introduction of coloured substances into them. Self-division has been seen in *Amœba diffluens.* No indications of a sensitive system are discoverable in any species. As only one genus is known, its characteristics are represented by those of the family.

This family, along with the *Arcellina*, form a very natural group of Infusorial beings, especially, characterized by their pulpy consistence, and variable expansions, serving the purposes of locomotion, and probably of prehension. This group has pretty generally received the appellation of *Rhizopodes*; a term derived from their root-like processes or feet. The extent of signification however, of the name, has, unfortunately, not hitherto been sufficiently determined upon: thus, Siebold (Lehrbuch der Vergleichenden, Anatomie, der Wirbellosen, Thiere. Von. c. Th. N. Siebold. Berlin, 1848. p. 11.) uses it for all the beings in the families, *Amœbœa* and *Arcellina;* whilst Dujardin restricts its use to the genera, included in the family *Arcellina*, (Ehr.) with some others, but excludes the *Amœba*.

The term *Rhizopoda* is useful to define the entire group, which may indeed be called a class. (See Page 58.)

Speaking of these peculiar animalcules, Siebold observes, that little is known of their internal structure, but they appear allied to the Infusoria. Their bodies may be compared to a simple cell, containing in their Parenchyma, a firm nucleous body, analagous to that of the Infusoria, no special organs can be distinguished unlike the true Infusoria. The *Rhizopoda* have no fixed form, no ciliated surfaces, but are moved slowly onwards by ramifying processes, protruded at various parts of the body, and continuous in substance with it.

Some of the *Rhizopoda* of Dujardin, are considered by Ehrenberg, to belong, not to the Infusoria, but rather to another order of beings, called by him *Polythalamia*, and by M. A. D'Orbigny, *Foraminifera*. The main difference, separating the *Rhizopoda* from the *Polythalamia*, is, according to Ehrenberg, the calcareous composition of the shells of the latter, and the siliceous constitution of the *Foraminifera*. Another general distinction between the two classes is, that whereas in *Polythalamia* the variable and gelatinous processes protrude through numerous regularly disposed holes, (foramina) in the shell, those of the *Rhizopoda*, on the contrary, escape from a single opening of greater dimensions.

The following account of the habits and appearance of the *Amœba*, given by Dujardin, convey a clear notion of those animalcules.

We may, in the first instance, perceive, on the glass slide, (under

the microscope) small rounded masses, semi-transparent or nebular, and motionless, but presently an expansion or rounded lobe, quite transparent, may be seen to proceed from the circumference of one or other of these masses; this expansion insensibly glides along the surface of the glass slide like a drop of oil, and then fixing itself at some point, slowly draws onward the remaining bulk.

In this mode the vitality of the *Amœba* is manifested, the expansions constantly varying in form, arrangement, and number, even in the self-same being. Some constancy in the form and proportionate size of the processes is however, met with in the different *Amœbæ*, and is employed in the discrimination of species.

Young *Amœbæ* are perfectly transparent, but in proportion as they increase in size, they lose their transparency by the accretion or imbibition of numerous corpuscles or granules, which have been looked upon as ova or the materials of nutrition. Amongst such particles, various matters, derived from without, are found thus imbibed or swallowed, such as starch granules, Naviculæ, vegetable debris, &c. Their mode of introduction is accounted for by the way in which the *Amœbæ* move along, their bodies being closely adherent to the surface to which they are affixed, and also so pressed as to take up any particles in contact, which by successive expansions and contractions become at length imbedded. Before admitting this interpretation of the phenomenon, Dujardin's assumption of the absence of an integument must be admitted.

But, further, the gelatine-form bodies of the *Amœbæ* are capable of having vacuolæ spontaneously formed, either at, or near the surface, which may ultimately collapse and disappear. By such means, foreign bodies may likewise become introduced within the organism.

"It is, however, difficult of belief, that these included particles, by reason of the consistence and unalterability of many of them, can serve to nourish the *Amœbæ*, but still, whilst admitting that the *Amœbæ* are nourished by absorption, I do not deny that they may find means of still more readily absorbing elements of nutrition, by swallowing various foreign bodies, and of thus increasing their absorbent surface. If it must in all cases be supposed that these foreign particles enter by a mouth, and are lodged in stomachs. It must also be allowed, that this mouth is produced at any spot, and

at the pleasure of the *Amœba;* to be presently re-closed, and to disappear, whilst that the stomachs themselves, devoid of any proper membrane, are hollowed out indifferently here and there, according to the requirements of the animal, to disappear after the same fashion; in this case only the words employed would differ, the explanation of the phenomena would remain as I have given it."

"Of other corpuscles or granules contained in the substance of the *Amœbæ,* some, of extreme tenuity, and irregular, appear to differ from the general gelatinous substance only in density, and I am induced to consider them a product of secretion rather than ova. They move about and appear to flow along with the glutinous mass in the expansions pushed out by the animalcule; they, in this way, aid the observer in detecting the very slow movements of the *Amœbæ.* The remaining sort of granules which, on account of their uniformity, ought, with better reason, to be looked upon as ova, are chiefly observed in the large *Amœbæ,* in which they are seen to move hither and thither, according to the position of the expansions thrust out, into which, indeed, they advance to a greater or less extent. But these ovoid bodies appear to me too consistent and too homogenous to be ova, they refract light, indeed, as strongly as starch granules." In fine—"I am disposed to regard most of the internal granules of *Amœbæ* as foreign to their organization."

"The *Amœba,* once developed, may doubtless multiply by spontaneous fission, or by the throwing off of a lobe which immediately commences an independent existence. The only experiment I have tried on this point in a large *Amœba,* has convinced me that, by the tearing or section of the mass, no escape of the internal glutinous matter, or of the contained granules occurs, but that each segment contracts on itself, and continues to live. In this may be found evidence of the non-existence of an integument."

"Ehrenberg attributes to the *Amœbæ* a resistant, contractile, and very elastic integument, and he explains the production of the variable expansions on the supposition that the integument becoming relaxed at some one part of its surface, at the will of the animal, there results therefrom at such spot, a sort of hernia, all the rest of the integument, by virtue of its contractility, compressing the viscera and internal organs into the dilated portion of the integument."

The external affinity of the *Amœba* with sponges is very close; they may indeed be called microscopic sponges. The resemblances are well conveyed by Mr. Carter, in the following interesting description of a fresh water sponge. "A ragged portion torn off with a needle, will be seen gradually to assume a spheroidal form; and if there be a spiculum, it will embrace it within its substance, it may even be seen to approach it, and it may bear away the spiculum, having, as it were, spit itself upon it. On its circumference, will be observed little papillæ, which gradually vary their form, extending and retracting themselves, until one of them may be seen to detach itself from the parent-mass and go off to another object. This little animal, one of the group which it has left, may remain stationary on the second object, or descend to the watch-glass, assuming in its progress all forms that can be imagined, spheroidal or polygonal; whilst every point of its body appears capable of extending itself into a tubular attenuated prolongation . . . . These transparent little sacs (the gemmules of Grant and Hogg) are sometimes filled with green matter. They appear to be able to adapt themselves to any form that may be convenient for them to assume, and when forcibly separated from each other (by tearing to pieces a minute portion of the sponge under water in a watch-glass), the isolated individuals may be seen to approach each other, and to apply themselves together in twos and threes, &c., and so on, until, from a particle, only discernible by the microscope, they assume the form of an aggregate mass, visible to the naked eye, and such a portion, growing and multiplying, might ultimately reach the size of the largest masses adhering to the sides of the tanks at Bombay. They appear to belong to the genus *Amœba* of Ehrenberg."

These changeable globules, Mr. Carter, in the subsequent part of his paper, designates Proteans; and states that they commonly resemble the *Proteus diffluens*, Müller. (Notes of the species, &c., of the Freshwater Sponges of Bombay. "Trans. Med. and Phys. Society, Bombay, 1847. Appendix.)

Genus Amœba.

A. *princeps* (*Proteus diff.* M.)—Body of a pale yellow colour, furnished with numerous variable processes, somewhat cylindrical in

form, with the terminations thick and rounded. This curious creature, from its slow motion and yellowish colour, is a desirable object for the microscope; its singular changes of form, and its internal organization, may be viewed with considerable pleasure, under very high magnifying powers. Its normal shape, if such it can be said to possess, is globular, but it can relax any portion of its body, and contract the rest, so as to force the internal part down into this relaxed portion, which thus becomes so to speak, a hernial tumour; ten or twelve processes may sometimes be seen extended at one time. Figures 85, 86, and 87, represent three animalcules highly magnified; the first has only two processes extended; in the last there are several. Found amongst *Naviculæ*. Size 1-140th to 1-70th.

AMŒBA *verrucosa.*—Body less than that of the last species, and colourless; globular or ovoid processes, very short and blunted, resembling warts; motion sluggish. Size never exceeding 1-240th.

A. *diffluens* (*Volvox sphoerula*, M.) Body expansible and colourless; processes longer than the last, strong and more pointed. This species is a very interesting object for the microscopic observer; its body resembles sometimes a transparent, at others a turbid lump of jelly, slowly expanding and stretching itself out, and here and there exhibiting its pointed processes, which again disappear as it advances. Its motions may be compared to those of a many-footed animal tied up in a sack. Found in Hackney Marsh, amongst Lemna. Usual size about 1-300th.

A. *radiosa.*—Body colourless, and less than that of the preceding species; its processes, which are numerous, are long and slender, pointed at the ends, and apparently radiating, This animalcule, when in a contracted state, is not distinguishable from the A. *diffluens*, but when fully expanded may be likened to a porcupine. It readily imbibes colouring matter. Fig. 88 resembles one of these creatures in a contracted state, and 88* the same with the processes thrust forth. Found in bog-water. Size 1-240th.

A. *longipes.*—Very small; processes very long; a single one, often four times longer than the body, acute, hyaline. Body 1-2500th. In North Sea, at Cuxhaven.

A. *Roeselii* (Duj.)—Diaphanous, expansions numerous, some very

obtuse, others digitate, and others also pointed or jagged. Size 1-130th. Large vacuolæ were noticed about the middle of the body looking like large globules.

Amœba *marina*, (D.) *Amœba*, filled with granules at the centre, and differing from the *A. diffluens* only in its dimensions and habit, *i. e.*, the sea. Length 1-260th.

A. *Gleichenii*, (D.)—Changing from a round globular to a very long oval figure, and dividing into two or three lobes at one extremity; it often exhibits vacuolæ, and nearly opaque nebular bodies at the centre Length 3-2600th to 7-2600th.

A. *multiloba*, (D.)—This may be but a variation of A. *Gleichenii*, but deserves pointing out as much from the circumstances of its appearance as from its form. Length 1-1300th. It seems softer than other species, and moves actively, emitting from its border in various directions ten or twelve rounded lobes, assuming thus a most irregular figure. It was found in an infusion of meal which had been kept nearly two months.

A. *limax*, (D.)—Body diaphanous, rounded at each end but slightly lobed, gliding along in a nearly straight line, containing very distinct granules, and a very clearly marked vacuola. Was found in the water of the Seine, kept for eight months. It may be but a more advanced degree of development of the preceding, or of the following species, its greater transparency, however, and its semi-fluid consistence, seem sufficiently distinctive. Length 1-260th to 1-800th.

A. *guttula*. (D.)—Diaphanous, orbicular or oval, gliding in a straight course, and containing very distinct granules. This is one of the most common species, but may easily escape notice on account of its great transparency, the simplicity of its form, and the slowness of its movements. Found in river or marsh water, kept for some time, and containing plants. Length 1-520th to 1-890th.

A. *lacerata*, (D.)—Body symmetrical, rugose, plaited, and granular, rather diaphanous, with broad expansions, as though membranous at the base, and terminated by several tapering torn points; one or more evident vacuolæ. Length 1-2800th to 1-890th. In pond water.

A. *brachiata*, (D.)—Body globular; semi-transparent, porous and tubercular, with four to six very thin, long, and cylindrical expan-

P 2

sions, straight or flexuose, sometimes bifid or branching. In animal infusions. Length 1-190th.

Amœba *crassa*, (D.)—More or less rounded, thick, containing numerous granules, expansions circular, numerous, not very prominent, Length 1-880th to 1-520th. In the water of the Mediterranean.

A. *ramosa*, (D.)—Body globular or ovoid, containing a great quantity of granules, and emitting numerous expansions of nearly equal size, rounded at their extremities, and of the same length as the body, and mostly branched.

Other varieties of these peculiar beings are referred to, but not specially described by Dujardin, to one, however, he proposes the name of *Amœba inflata*.

Dujardin appends the following observations:—

"It is impossible to establish Zoological species in the case of animalcules, having no determined form, without appreciable organization; the mode of origin and of reproduction of which, are alike unknown, and upon which we may suppose the nature of the liquid produces very great changes. For, from what precedes we may conclude, that most of the *Amœba* described, are developed in saline solutions, more or less saturated, and often also in liquids, having their fluidity diminished by organic matter held in solution."

Family.—ARCELLINA.

This family contains polygastric animalcules, which possess an alimentary canal, a single opening of the body, are provided with a lorica, and can change their figure by means of variable pediform processes. The lorica, which is univalved, is pitcher or dish-shaped, and the possession of it is the chief feature, distinguishing this family from the *Amœbaea*. The body is soft and gelatinous, and in some cases appears to flow, as it were, from the opening of the lorica. The organs of locomotion are soft variable processes, situated at the anterior part of the body; they are sometimes withdrawn, at others protruded; sometimes they appear simple, at other times branched. In five species, numerous digestive vesicles are seen. No traces of a sensitive system have been discovered. The reproductive system

is unknown, neither has increase by self-division, by the formation of gemmae, or otherwise, been recognized.

The shell or lorica of the *Arcellina* or *Rhizopodes*, varies much in figure, and especially in the condition of its surface, which may be smooth, or variously, and oftentimes beautifully sculptured, or beset with spires or other prominences. The *Rhizopoda* have a close affinity to the *Polythalamia* or *Foraminifera;* indeed, some authors, as Dujardin and Schlumberger, describe as *Rhizopodes*, several genera placed by others—Ehrenberg, D'Orbigny, &c., among the *Polythalamia.* These doubtful genera include beings with more complex loricæ, than those strictly of an Infusorial character.

In determining the various species of *Arcellina*, the dimensions, figure, and other circumstances pertaining to the opening (mouth) of the lorica, are of great importance, The loricæ may often be found empty, they may be frequently seen tinted orange-yellow, or brown; their consistence also varies, from a flexible parchment-like material, to a brittle siliceous (calcareous) substance. Some of the *Rhizopoda* attain such dimensions, as to nearly fall within the compass of unaided vision.

Some are marine; others as the *Difflugia*, live in fresh water. Concerning their habit, we may quote Dujardin's account, who says; "The *Rhizopodes* being deprived of the power of swimming, and compelled to merely crawl (glide), when not fixed to the surface of bodies, are consequeutly to be met with only upon aquatic plants, between the leaves, which afford them shelter, or in the stratum of debris, about the base of such plants, or between the asperities of the shells of marine mollusks. They are not met with in infusions, although they will live a long time in bottles containing any plants, which may serve them for an abode, and in such cases they will very soon be found crawling on the surface of the glass, and be easily observed."

Speaking of the affinities of the *Foraminifera*, D'Orbigny remarks, "From what precedes concerning the characters of the *Foraminifera*, it is evident they cannot be arranged under any known class of animals. . . . . Their place in the animal kingdom is, as an altogether independent class between the *Echinodermata* and *Polypes;*" (Foraminiferes fossiles du Bassin, Tertiare de Vienne, p. 17, 1846.)

M. Agassiz, on the contrary, would elevate them among the *Gasteropoda.* (Annal Nat. Hist., 1850, p. 156.)

The genera are related to each other as follows :—

Changeable processes radiant, generally numerous	Lorica spherical or tun-like...............	Difflugia.
	Lorica a flat spiral...............................	Spirillina.
	Dish or shield-shaped.........................	Arcella.
Changeable processes broad and undivided		Cyphidium.

Dujardin divides the *Rhizopodes* into two sections, According to the form of the variable expansions, "The first section corresponds to the family *Arcellina* of Ehrenberg, and comprehends those species provided with short thick expansions, rounded at the extremity. Such are the *Difflugiæ,* possessing a flexible membranous lorica, without visible texture, mostly of globular form, whence radiate the expansions: such too, are the *Arcellæ,* having a discoid lorica, flattened on the side, along which it moves (the plane of reptation), where is a central round opening, from which the expansions proceed, the latter lying thus between the shell and the surface, along which it glides. The lorica is, moreover, brittle, often reticulated, or areolated, and indications of a spiral; not a symmetrical arrangement present. The second section much larger, comprises all th varieties of form, presented by filiform expansions, very fine at the extremity. Of these varieties I make three tribes; the first distinguished from the *Difflugiæ* only by the slender character of the expansions; however, in one genus of this tribe *Trinema,* the opening is lateral; and certain species, forming the genus *Euglypha,* have a lorica beset with tubercles, or areolæ, disposed spirally; whilst the third genus *Gromia,* has a spherical membranous shell, and very long and branching expansions."

The remainder of the *Rhizopodes,* as described by Dujardin, are located by other authors with the *Polythalamia,* they are marine animals, having a calcareous shell, mostly very delicate and elegant, and presenting a miniature, as it were, of the *Nautili* and *Ammonites,* but always divided into many cells (chambers.) Out of these beings, Dujardin constitutes two other tribes of his so-called *Rhizopodes:* one represented by the single genus *Miliola,* which, like *Gromia,* and the other examples of the first tribe, has but a single

large opening in its lorica for the escape of the expansions; the other, by numerous genera, in all which numerous filiform expansions emerge from many distinct pores (foramina); hence the name applied to them by D'Orbigny, of *Foraminifera*, and by Ehrenberg, of the Greek equivalent, *Polythalamia*.

Of these porous animalcules, Dujardin cites but the subsequently named genera, viz., *Vorticialis, Cristellaria, Rosalina,* and *Planorbulina*.

Reference to the system advanced by Siebold, page 62 will show that this naturalist in forming his class *Rhizopoda*, has included in his family *Arcellina*, the genera constituting the first and second tribes of Dujardin, and has created an order, *Polysomatia*, for the undoubted *Polythalamial* genera, *Vorticialis, Geoponus* and *Nonionina*.

In the ensuing descriptions of the species *Arcellina*, we shall confine ourselves to the beings embraced in the *Arcellina* of Ehrenberg, and in the two first tribes of the second section of the plan of M. Dujardin. For an account of the *Palythalamia* or *Foraminifera*, we may refer to the splendid work of D'Orbigny, before named, and to the various papers of that author, and of Professor Ehrenberg.

Genus Difflugia. *The diffluent Animalcules.*—This genus is characterized by the creatures having the variable processes, which issue only from the fore part of the body, numerous, or each one cleft into several parts, so as to give it the appearance of being many. The body is enveloped in a horny pitcher-like lorica, sometimes globular, at other times oblong or spiral in form, and either smooth or sculptured. The lorica of this genus being opaque, except in *D. enchelys*, little of the internal organization of these creatures is known; in *D. enchelys*, numerous digestive cells have been seen. In *D. proteiformis* and *D. acuminata*, the lorica is covered with grains of sand, similar to that of the caddis-worm. In *D. oblonga* and *D. enchelys*, the shell is smooth.

D. *proteiformis*.—Lorica ovate and subglobose, as represented in figs. 89, 90, and 91: it is roughly coated with minute grains of sand, and is either of a blackish or greenish colour. The transparent processes vary in number from one to ten. In fig. 89, six are protruded. M. Le Clerc describes this species as having spiral corru-

gations on the lorica, which Ehrenberg does not appear to have seen. Found among Oscillatoria, &c. Size 1-240th.

Difflugia *oblonga.*—Shell oblong, rounded, smooth, and of a brownish colour. The transparent processes fewer and stouter than those of the preceding species. Found among Oscillatoria, &c. Length 1-200th.

D. *acuminata.*—Shell oblong and rough, being covered with minute grains of sand; posteriorly pointed; processes transparent. Length 1-70th.

D. *enchelys.*—Shell oval; colourless; transparent and smooth, rounded on the back; processes transparent, slender and small; aperture lateral. This is the smallest species of the genus. Size 1-550th. Found in stagnant water.

D. *ampulla.*—Lorica oblong, club-shaped, elegantly marked by an oblique series of dots *(puncta)*: hyaline, with an ovate opening. Size 1-680th. Found by Dr. Werneck at Salzburg.

D. *spiralis,* (Bailey).—Lorica sub-globose, minutely granulated: upper surface unequal, with a spiral suture of two or three turns. Pseudopodia, (variable processes) long, numerous, constantly changing positions, hyaline. Size 1-680th. Found at Berlin, and common in the United States.

D. *acanthophora.*—Lorica ovate, oblong, areolated, loosely foramen dentated, armed posteriorly with three or four spines (*aculei).*

D. *areolata.*—Lorica and foramen, as in the preceding, but the spines deficient.

D. *denticulata.*—Lorica ovate, oblong, smooth, foramen (mouth or ostiola) with twelve dentations,

D. *lagena.*—Lorica clavate, of the form of a bottle, smooth, without reticulations, margin of opening entire.

D. *lævigata.*—Lorica ovate, oblong, smooth, foramen with eight dentations, approaches *D. denticulata.*

D. *striolata.*—Lorica ovate, oblong, delicately striated longitudinally; foramen with a dentated border.

D. *bructeri.*—Lorica ovate, surface rugose, the end presenting the aperture rather attenuate but truncate; margin of aperture entire. Length 1-1050th. Found on moss.

D. *cancellata.*—Lorica oblong, obtuse; surface beset with imper-

fectly rounded cells, 5—6 in 1-2500th; aperture narrow, entire. Length 1-1040th. Found on moss.

Difflugia *ciliata.*—Lorica ovate, surface areolar; each posterior areola furnished with a cilium or cirrhus; constricted towards the foramen which has 10 to 16 denticulations. Length 1-936th. Common in Hercynia.

D. *seminulum.*—Lorica shorter, ovate, brown, surface with narrow and small areolæ, aperture wide, very finely denticulated or entire. Length 1-2500th to 1-1250th. On moss and stones.

D. *collaris.*—Lorica formed like a neck behind the aperture; straight, attenuate, pyriform or sub-clavate; surface irregularly cellular, the cells small, but of equal size, except about the neck, where they are smaller; aperture entire. Length 1-840th. About roots of trees.

D. *dryas.*—Lorica ovate, with longitudinal linear rows of ovate cells; aperture entire, truncate. The size of cells decreases posteriorly. Length 1-1170th. On roots of trees.

D. *oligodon.*—Smooth, oblong, sub-cylindrical, aperture with eight strong denticulations. Length 1-1000th. This species and the two following found in Kurdistan.

D. *reticulata.*—Lorica ovate, surface broader, marked by a network of minute cells; aperture simple, large. In its interior are numerous particles like aggregated buds; or the margin of the foramen may be furnished with dentations. Length 1-880th.

D. *squamata.*—Lorica ovate, with large loose areolæ looking like scales (squama); aperture with denticulations, truncate contracted. Length 1-1450th.

The next species, is from Dujardin, those following from Schlumberger. (*Annales des Sciences Nat.* 2*mo. Series,* vol. iii. 1845, p. 254.)

D. *globulosa.*—Lorica brown, globular, or ovoid, smooth. Length 1-260th to 1-105th. Found near Paris.

D. *depressa.*—Lorica diaphanous, ovoid, depressed, resistant; its surface divided by slight fissures (lines) into numerous small and irregular polygonal sections. Length 1-220th. Aperture with an uneven margin. Found in springs, Vosges.

D. *gigantea.*—Lorica, greyish, brown, rough as if screwed with

particles of sand, ovoid, elongated, and contracted anteriorly. Length 1-325th to 3-325th. It approaches *D. proteiformis*, but differs in its more elongated form, in being contracted anteriorly and almost pyriform, in being sometimes depressed, and lastly in its greater size: margin of aperture uneven.

Genus Spirillina.—Lorica tubular, siliceous, rolled in a spiral manner, resembling the shell of a *Planorbis*. It is allied to *Difflugia*, with a siliceous lorica—acids exert no action on the shell. This genus probably agrees with the *Spirulina* of Bory St. Vincent, but the latter name has been otherwise used by Ehrenberg to designate a genus of *Polythalamia*.

S. *vivipara*.—Shell porous, convoluted as a circular, spiral, horizontal tube, hyaline and smooth. Young loricæ may often be found connected with it. (P. 14. f. 37.) Found living in the sea—Vera Cruz, Mexico.

The form of this species recalls that of many undoubted *Polythalamia*, whilst it has no fellow among the Infusoria. Ehrenberg has likewise represented apparent dots or pores on its surface, like those through which the filiform processes of *Polythalamia* are protruded; and the only reason implied in Ehrenberg's account of this organism, to reckon it among the *Polygastrica*, is, its siliceous shell. It will be noted that Ehrenberg is inclined to believe it viviparous.

Genus Arcella. — *The capsule Animalcules* possess numerous variable processes, or single processes, cleft into many, and spread abroad, and is furnished with a flattened shield-like lorica. The structure of the lorica, as to details, is very different in the various species. For instance, in *A. vulgaris* it exhibits regular and delicate facets; in *A. dentata*, the facets are large and crystalline; in *A. aculeata*, it is beset with spicula, and in *A. hyalina*, it is homogeneous and clear. The organs of locomotion are extensile and retractile processes, radiant and variable. The digestive cells are readily filled with coloured vegetable substances. In *A. vulgaris*, a contractile vesicle has been perceived.

"The *Arcellæ* (says Dujardin,) seem to differ among themselves by the intimate structure of their lorica, which sometimes appear membranous, at others finely striated, reticular, or with granules disposed in spiral lines. Some *Arcellæ* have also spinous prolongations

from the border of their lorica. Pressure fractures their lorica like a brittle substance. By the cracks so formed, the contained substance escapes, extending in the form of contractile expansions, as in the *Amœbæ*. I have seen one larger lobe almost separated, as if about to become an independent being. M. Peltier has observed contact to take place between the expansions of neighbouring *Arcella* without any union being effected, while the processes of the same *Arcella* will unite and become blended together.

The lorica in young *Arcella* is extremely diaphanous, and granulations or striæ are to be seen only in those of larger size, hence it may happen with respect to some species that they represent but different stages of existence of the same animal."

A. *vulgaris.*—Lorica, round and bell-shaped, with a hemispherical or turgid back; smooth, and composed of rows of minute granules; colour yellow or reddish brown. Found abundantly amongst lemna and aquatic plants. Size 1-570th to 1-240th.

A. *aculeata.*—Lorica hemispherical, though often mis-shapen and spinous at the margin. It is formed of short spicula, and is of a yellowish colour. The spines sometimes issue from only one-half of the margin of the shell, or shield-like lorica; the shell is not readily destroyed by heat. Fig. 92 represents one of these creatures with the projecting spines, and the large round opening in the lorica. Fig. 93 represents another creature with three spines projecting from its lorica, and a single variable process issuing from the under side; the digestive cells may also be seen. Fig. 94 shews an empty deformed lorica. Diameter of lorica 1-210th.

A. *dentata.*—Lorica membranous and homogeneous; of an hemispherical or polygonal form, having the margin dentated; colour yellowish or greenish. Found amongst conferva. Size 1-570th to 1-240th.

A. (?) *hyalina.*—Lorica membranous, smooth, and approaching to globular, smaller than the preceding; colourless. Found in matter deposited by water, along with *Cyphidium aureolum*, &c. Size 1-1150th to 1-570th.

A. *Americana.*—oblong; aperture small, round, not in the median line.

A. *constricta.*—Lorica ovate; slightly contracted about the foramen, which is very large and to one side.

ARCELLA *disphæra.*—Oblong; almost divided into two by a central constriction; one-half nearly occupied by the large foramen.

A. *ecornis.*—large; hemispherical, not areolar; aperture round, large, placed to one side, entire.

A. *lunata.*—Lorica sub-globose, large; with a large semi-lunar opening, seated to one side.

A. *Nidus-pendulus.*—ovate; oblong, hyaline, loosely areolated; aperture in front, oblong, margin entire.

A. *pileus.*—Lorica hemispherical, depressed, reddish, minutely and elegantly areolar; aperture central, circular.

A. ? *globulus.*—Sub-globose; with loosely reticular lines, appearing granular; aperture large, simple. Diameter 1-730th. Found on moss at Berlin, Potsdam, &c.

A. *granulata.*—Oblong; hyaline. Has the habit and size of *A. hyalina* with a granular instead of a smooth surface. Length 1-940th. On moss in Hercynia, &c.

A. *caudicola.*—Lorica ovate, oblong, rounded at each end, hyaline, very delicately hispid, not areolar; aperture anterior, round, large. Length 1-840th. Habit of *A. Nidus pendulus.* Found in Venezuela, on roots of plants, such as ferns, &c.

Genus CYPHIDIUM.—This genus is distinguished by the creatures having only one dilated variable process, and a lorica of the form of a pitcher, with protuberances issuing from it. It forms a connecting group between *Arcella* and *Bacillaria,* by reason of the simple locomotive organ (like a snail's foot), and approaches very closely to the group *Desmidieæ.* The lorica is something like a little die or stamp, mounted upon a short stem. It is very irregularly formed, having protuberances so as to make it appear four-cornered; it is combustible. The organ of locomotion is a broad, gelatinous, variable process, with smooth edges, resembling in appearance the body of *Amœba verrucosa.* Neither digestive cells or apertures in the lorica have yet been observed, nor organs of sensation, or of propagation.

C. *aureolum.*—Lorica of a cubical form, with protuberances; process colourless. In March, 1835, says Ehrenberg, "I first observed hundreds of these creatures in a glass of water, which had stood throughout the winter, in company with some specimens of the *Micrasterias.* Previously to discovering these, the *Amœba verrucosa*

had been abundantly generated; and, after their discovery, *Arcella hyalina*. The creatures were inactive, although, with attentive observation, they might be seen to change their places." Ehrenberg only once perceived the locomotive organ of the animalcule, situated under one corner, upon which it appeared to rest, and that so firmly, that six out of the eight protuberances of the die-like lorica were visible at the same time. Figs. 95, 96, and 97, represent these creatures in different positions. In the second, the gelatinous variable process is seen projecting from beneath the lorica; in the other two figures, the lorica only is visible. Fig. 98 is a young specimen. Size 1-570th to 1-430th.

The first four of the ensuing appended genera are from Dujardin, the others from Schlumberger. (An. des Sciences, Zoologie, 1845.)

Genus Trinema.—Shell membranous, but resistant, diaphanous, ovoid elongated, narrower in front, with a large oblique orifice placed laterally; expansions filiform, as long as the shell, very thin, and but two or three in number, entirely retracted when expansions are to be pushed out from another side, and moving the animal onward by their contraction.

T. *acinus*. = *Difflugia Enchelys*. (Ehr.)

Genus Euglypha.—Shell diaphanous, membranous, resistant, of an elongated ovoid form, rounded at one end, terminated at the other by a very large truncated orifice, with a dentated margin; its surface marked by eminences or depressions, in regular oblique series; expansions filiform, numerous, simple.

E. *tuberculata*.—Lorica striated with rounded tubercles. The termination of its expansions are extremely delicate. Length 1-295th. Found in stagnant ponds.

E. *alveolata*.—Lorica with regular polygonal depressions in regular oblique (spiral) series. Length 1-290th.

Genus Gromia.—Lorica smooth, yellowish brown, membranous soft, globular, with a small round opening, from which the very long branching expansions proceed, tapering to very fine extremities. Found in both salt and fresh water.

G. *oviformis*.—Globular, smooth, aperture surrounded by a short

neck, expansions branching, but slightly anastomotic. Size of shell 1-26th to 1-13th. Length of expansions one-half.

GROMIA *fluviatilis.*—Globular, or ovoid, without a neck; expansions palmate and anastomotic. Diameter 1-290th to 1-104th.

G. *hyalina,* (Schlumberger). — Lorica globular or rather ovoid, smooth, soft, diaphanous, colourless; foramen round, with a very short neck, formed by a reflection of the lorica; expansions filiform, numerous, very fine, branching and anastomotic. Diameter 1-865th to 1-520th. In rivulets.

"Notwithstanding the absence of colour in the shell, (says Dujardin), I arrange this species in the genus *Gromia.* In size it also differs from the other two species. The lorica being transparent, admits to view, some blueish globules, and a large hyaline glandular ovoid body, like that in the interior of other diaphanous *Rhizopodes.*"

Genus MILIOLA.—Lorica calcareous, ovoid, or depressed, having but a single opening, consisting of several cells variously disposed. Expansions filiform, radiating from the single orifice, which is bifid, by the projection into it, on its inner side of a tongue-like process.

The lorica is compact without pores, and either smooth, or variously marked by ribs or striæ. Expansions very fine.

Examples of this genus are very numerous in a fossil state with other *Polythalamia,* often constituting the chief components of large masses of earth. Many of them are also visible to the naked eye.

Genus LECQUEREUSIA, (Schlumberger). — Shell ovo-globular, or retort-shaped, rather depressed, membranous, but resistant; with a wide short neck, and circular terminal aperture, giving passage to cylindrical, thick and obtuse expansions.

This genus approaches *Difflugia,* (Duj.) in the character of its expansions, but the very different form of the shell, and the position of the aperture, sufficiently mark the distinction between the two.

L. *Jurassica.* — Shell resistant, diaphanous, grey, of a globular figure, but rather depressed with a short wide neck. Length about 1-250th. Breadth 1-315th.

This beautiful species is met with on aquatic, or other dead plants, in many of the lakes of the Jura chain about Nefuchatel. Its diaphanous lorica allows its interior soft hyaline and granular body, strewn with brown specks, to be seen.

Genus CYPHODERIA.—Lorica membranous, resistant, ovoid elongated anteriorly, where it is curved, and constricted in the form of a neck; surface marked by prominent points in oblique rows; aperture circular, oblique, expansions very long, filiform, very fine at the extremity, and simple or branching.

The oblique disposition of the rows of points, the obliquity of the aperture, and the character of the expansions, bring this genus into affinity with *Trinema* (Duj.); but the interior constriction, forming a neck, seems sufficiently distinctive between the two.

C. *margaritacea.*—Lorica yellow; the translucent points looking like rows of pearls. Processes attain twice the length of the shell. Length 1-395th. Breadth 1-840th to 1-408th. Common in the water of the Vosges with vegetable debris. The form of the lorica varies; at one time the neck may be but rudimentary; at another the posterior end, instead of being wide and rounded, is contracted suddenly to a truncated apex.

Genus PSEUDO-DIFFLUGIA. — Shell membranous, ovoid, or ovo-globular, smooth or striped spirally, with a wide round opening, whence proceed numerous long, slender expansions, either simple or branching.

This genus is allied to *Difflugia* by the form and character of its shell, but differs from it in the nature of the expansions.

P. *gracilis.*—Shell bluish brown, brittle; surface, as if beset with minute grains of sand, of a more or less elongated ovoid figure, expansions filiform, very long. Length 1-740th to 1-465th. Breadth 1-890th to 1-740th. Found near Mulhouse.

Genus SPHENODERIA.—Shell diaphanous, colourless, resistant globular, with a flattened wedge-shaped neck, surface marked by polygonal depressions, disposed in regular oblique rows; aperture terminal, compressed, almost linear. Expansions filiform, very long and attenuated.

The form of the aperture and of the neck separate this genus from *Trinema* and *Euglypha*, to which it is allied by the structure of its lorica.

S. *lenta.*—Lorica as above described, expansions few, very long, slender, and simple, or branching. Length 1-650th to 1-520th.

"Of all the *Rhizopodes* (says Dujardin) this is the slowest in its

movements, and its expansions the most difficult to discover. I have found it on tufts of moss in marshy rivulets."

In the internal soft substance, are seen near the posterior end, a glandular body and hyaline globules. In moving, the position of the shell may be perpendicular, or oblique to the surface of reptation. the hexagonal depression are indistinct but large. The shell fractures along the lines of junction between the hexagons.

Family—BACILLARIA.

In re-writing the account of this very extensive and important family it will be advisable to retain much of the original text, and to present most of the more recently obtained particulars together with the various views entertained by authors, as an introduction to each section, namely, the *Desmidiacea* and *Naviculacea*, into which the *Bacillaria* are divided.

The first observers of this family considered its members animals; but the greater number of modern naturalists regard them as plants, and place them among the minute algæ; hence it is, that we stand indebted to the botanist for much of our knowledge of their forms and localities. Again, some of the genera are considered by philosophers to be the connecting links between the animal and vegetable kingdoms.

Although, as before observed, there does not exist any distinct line of demarcation to separate animals from plants, similar to that which exists between organic and inorganic bodies, yet, with respect to the animal or vegetable nature of the *Bacillaria*, after careful examination of the proofs offered on both sides of the question, it appears to me that their position among organized beings, stands at present as follows:—

Vegetable	....	Algæ.
	Bacillaria............	Desmidieæ.
		Naviculacea.
Animal	....	Polygastrica.

Professor Bailey, of New York, in his recent valuable "Microscopical Observations made in South Carolina, Georgia and Florida,"

appends to one of his tables of fossil organisms discovered by him, the following excellent remarks:—

"I have separated the *Desmidieæ* and *Diatomaceæ, (Naviculacea),* from the Infusoria, and I have done so, because many distinguished observers now consider these groups as decidedly belonging to the vegetable kingdom. While I believe that no accurate line of separation can be drawn between vegetables and animals, I am yet disposed to consider the *Desmidieæ*, from the sum of all their characters as most nearly allied to the admitted vegetables, while the *Diatomaceæ,* notwithstanding Thwaite's interesting observations on their conjugation, still seem to me, as they have always done, to be true animals. There is such apparent volition in their movements, such an abundance of nitrogen in the composition of their soft parts, and such resemblances between the stipitate *Gomphonematæ,* and some of the *Vorticellæ*, that I should still be disposed to class them as animals, even if Ehrenberg's observations of the retractile threads and snail-like feet of some of the *Naviculæ* should not be confirmed."

Ehrenberg, (whose skill and practice in the use of the microscope has been very great,) affirms that all the members of the family *Bacillaria* are decidedly animal, and characterizes them as comprehending all animalcules, distinctly or apparently polygastric, destitute of alimentary canal; the body furnished with variable undivided processes, and covered by a lorica or shell. While undergoing self-division they appear connected together, as it were, by a percurrent thread, so that they form chain-like or tabular groups. The lorica of each animalcule has one or more openings, and at the places where these creatures are connected together, the union is effected by means of soft processes protruding through these openings. Excepting *Navicula,* and one or two other genera, they never separate spontaneously into single individuals, but always adhere, forming polypi-like concatenated masses of greater or less extent; hence it is that the term *imperfect* self-division has been applied to their mode of propagation.

This family is of vast importance in a geological point of view, and the valuable observations of Professor Bailey, on the fossil forms of America, are of deep interest; indeed, the labours of that eminent

naturalist in this department has far surpassed those of any european observer, if we except Ehrenberg, (See section *Naviculacea*).

The composition of the lorica or shell in this family is various, and may be separated into two kinds; the first containing silica, either pure or in combination with the oxide of iron; forming a silicate of iron; the second, those in which silica is entirely absent, when the lorica has a membranous or parchment-like (structure) texture. It is remarkable that in no case has lime been found to enter into their composition. In some genera the lorica is surrounded by a soft gelatinous variously-formed envelope or induvium. The shape of the lorica is various, but such as entirely to inclose the internal organic portion, except the parts where it is united with others; hence it is termed *urceolate.* The lorica is composed of two or more shells, or pieces, termed valves, which are usually dish or cup-shaped, and often fluted (striated) or grooved. Those in which silica enters into the composition have usually a round or a prismatic four-sided figure, while, in the non-siliceous, they are generally flat, with three to five sides.

Of the internal organization of these creatures little is known, owing to their opacity, and the structure of the enveloping lorica. In many, however, large transparent variable vesicles are seen among the mass of coloured granules which occupy the greater part of the lorica. These vesicles are considered by Ehrenberg to be digestive cells, and the coloured mass (the chlorophyl of botanists,) ova. In some species, as soon as the coloured ova are protruded, the parent dies; in others, the ova form a Monad-like mass, from which when matured the parent separates; hence, says Ehrenberg, has arisen the opinion of the transition of animals into plants. In *Micrasterias, Anthrodesmus,* and one or two other genera, says Ehrenberg, male reproductive structures are visible, but no trace of a sensitive system has been discovered.

From the clustering nature of this sluggish family, and the rigidity of their coverings, they resemble the confervoid Algæ, and other minute vegetable forms, and are hence confounded with them; but in their mode of propagation a distinction may be recognized. In the *Bacillaria,* the self-division is always longitudinal, so that the

conferva-like forms are not composed of long slender and filiform bodies, like plants, but of short and broad filiform portions Sometimes the self-division is from back to front, or from side to side; the single creatures are then band-like, or half-moon-shaped.

In *Navicula*, Ehrenberg has described a locomotive organ possessing the power of moving in any direction, and accommodating itself to any form, similar to that curious muscular organ, the tongue, in animals, or to the foot-like process of snails.

The shells of these creatures are often sculptured with deep flutings; where this occurs, the inside of the shell is not always smooth, but follows the form of the exterior: thus the strength is greatly increased, while the quantity of solid material employed in their construction is not augmented. The flutings (striæ) in the living specimens being filled with coloured matter, are discerned with difficulty, and hence they are almost unknown. In the fossil state, the shells are empty, and then the flutings and other indentations become distinctly visible. I have, therefore, in the engravings illustrating this family, selected drawings of several in both states, so that the reader may form a clear conception of their true characters, while the interest attached to the family generally is so great, and we possess so few drawings of its various species, that I have been induced to extend the number of illustrations considerably. The order of their arrangement differs from that given in the plates of *Die Infusionsthierchen*; in that work the species and genera are placed in plates indiscriminately, and no regular arrangement is observed. As some fossil specimens have been discovered since Ehrenberg's great work appeared, I have had drawings of the finest I could procure, made for me; some of them are the last productions of my friend, the late F. Bauer, Esq.; so that the numerous illustrations of this family, whether the members be considered as animal or vegetable, will, I believe, be highly acceptable both to the botanist and zoologist.

The remarks in the last paragraph refer to the engravings of the first edition, all of which are retained in the present one, while most of the numerous figures in Plates 13 to 20, are additional illustrations of the *Bacillaria*.

In this family we are not only presented with the simplest forms

of organic matter, but, from their numbers and the indestructibility of their shells, they have led to many important discoveries. The large masses of meteoric paper which fell in 1686 have recently been shown to consist mainly of their coverings, while several hundred square feet of a flannel-like substance, lately found near Sabor, in Silesia, after an inundation, was composed of *Flagilaria, Navicula, Cryptomonas*, and *Closterina*, interwoven with Conferva rivularis.

As microscopic objects, the markings of the fossil species are highly interesting; and when mounted as opaque objects, a verification of the structure of their shell is clearly demonstrated.

Ehrenberg's primary division of this family is into single and double-loricated animalcules; the genera comprised in the first being again separated into those which are *attached*, by a pedicle or stalk, and those which are destitute of such appendage, or *free*.

The further distribution of the genera, by Ehrenberg, will be seen in the following table:—

Lorica simple.	Free.	One valved. (*Desmidiacea*).	prism shaped	three-sided		Desmidium.
				four-sided		Staurastrum.
				five-sided		Pentasterias.
			globular	smooth	clusters moniliform	Tessararthra.
					do. berry-like	Sphaerastrum.
				spinous		Xanthidium.
			flat	band-like	compressed or lying together	Arthrodesmus.
					united by serritures	Odontella.
				plate or disc-like	many in each plate or disc	Micrasterias.
					two ditto	Euastrum.
					single and disc-like	Microtheca.
		Two or more valved. *Naviculacea.*	round	spherical, simple		Pyxidicula.
				forming coral-like clusters	1-celled, articulated filiform	Gallionella.
					many celled, concentrically	Actinocyclus.
			prismatic	self-division complete never band-like	six openings to lorica	Navicula.
					four ditto	Eunotia.
					one ditto	Cocconeis.
				division incomplete, forming-band-like clusters	jointed: wand-like	Bacillaria.
					jointed: plate-like	Tessella.
					jointless (fragile): bands straight	Fragilaria.
					jointless (fragile): bands spiral	Meridion.
	Attached. (*Echinellea*)	single individuals broader than long				Isthmia.
		do. longer than broad	stalkless, sessile	formed as a wand (prism-shaped)		Synedra.
				formed as a wedge		Podosphenia.
			stalked	wedge-shaped	dichotomous by long. div.	Gomphonema.
					whorled or radiating by do.	Echinella.
				lance-shaped, attachment direct		Cocconema.
				banner-like attachment oblique	a central opening	Achnanthes.
					no central opening	Striatella.
Lorica double.	Covered with an amorphous mass of gelatine			scattered		Frustulia.
				connected in a ring-like manner		Syncyclia.
	Covered with membranous or gelatinous tubes			tubes simply branched	spiculi straight	Naunema.
					ditto crooked	Gloeonema.
				ditto aggregated, bundle-like	slit like a bunch	Schizonema.
					branched like a tree	Micromega.

The views of Ehrenberg on the *Bacillaria*, have, from their first promulgation, had many objectors, whose arguments were well brought together by Dr. Meyen, and are as follows:—

"Professor Ehrenberg has described and represented, in his great work upon the Infusoria, a very considerable number of organized bodies, looked upon by botanists as belonging to the vegetable kingdom. In these representations, naturalists have been able to attain what has been long desirable; for, although in respect to the more highly developed and complete vegetable beings, the truest delineations are indispensably necessary at the present day; it is much more requisite that *every one* of these lower and microscopic organisms should be laid before us in the same tangible manner. To the systematist, it is of no import whether these beings are represented as plants or animals, for one thing is certain—*they will always remain what they are.* In this work, Ehrenberg has not only given systematic descriptions of these questionable animals or plants, but his own observations, coupled with those of his predecessors, upon the nature of these bodies, are found copiously detailed. This, however, is apparent; all the facts known upon the subject are interpreted in a manner as if these creations were undoubtedly animals, whilst the same facts would indicate quite a different signification if we proceeded upon the supposition that they were nothing but plants. It now becomes a question as to which view is right, or whether we are able to prove positively either one or the other. The subject, however, is one of high importance, and we shall say a few words upon it, bringing forward those genera as illustrations of the subject, which, according to my own opinion, are decidedly composed of plants. The first little plant we find described and represented in Ehrenberg's work is *Gonium* (?) *tranquillum* (E.) This I discovered in 1828, gave a representation of it, and afterwards named it *Merismopedia punctata.* Ehrenberg himself has observed nothing animal with respect to this plant, which belongs to the *Ulvaceae*, and distinguishes itself remarkably by its continual regular self-division. The members of the genus *Closterium* belong just as decidedly to the vegetable kingdom as does the *Gonium;* but the following reasons are adduced by Ehrenberg as proofs of their animal organization. They possess voluntary motion; they have openings at the extremity; they possess

continually moving even protruding organs immediately behind the openings, and they are endowed with transverse self-division. But all plants, says Ehrenberg, which are endowed with voluntary motion, open orifices, feet, and self-division, we may look upon as animals, without waiting to see them eat. That this last resolution is correct, no doubt all botanists will accede to; but the following considerations are those which incline to the opinion of the vegetable nature of the *Closterina*. The structure of the *Closterina* is evidently that of the Conferva, as well as the formation of their spores or seeds, and the development of them. The existence of amylum (starch) within the *Closterina* is a striking proof of their vegetable nature. They are likewise destitute of feet, for what Ehrenberg took for these appendages are self-moveable molecules, as are seen in *Closterium trabecula*, to the number of 500 or 600, or more, and filling a canal running along the whole length of the plant. The function of these bodies it is very difficult to determine; but they are to be found in very many Conferva, and are perhaps to be likened to the spermatic animalcules of plants.

"Under the great family *Bacillaria*, Ehrenberg has brought thirty-five to thirty-six genera; but which may be more properly divided into two separate families—the family of the true *Bacillaria*, and that of the *Desmidiacea*. This last family has already been firmly settled by Menegheni, and includes those true *Algae*, concerning whose nature there can be no doubt. To the true *Algae* belong the following genera of Ehrenberg's *Bacillaria*:—*Desmidium* Ag.; *Staurastrum*, Mey.; *Pentasterias*, Ehr.; *Sphaerastrum*, Mey.; *Xanthidium*, Ehr.; *Scenedesmus*, Mey.; *Odontella*, Ag.; *Pediastrum*, Mey. (*Micrasterias*, Ag.); and *Euastrum*, Ehr. In all these genera, nothing has yet been observed which can be adduced as evidences of their animal nature. Actual motion, arising from internal causes, I saw only in *Sphaerastrum;* and the slight movement, supposed to have been observed in some of the genera, is certainly of the same description as that of some Conferva, which sometimes vegetate far below, at other times upon, the surface of water; but this elevation from the deep is generally connected with visible evolution of gaseous matter. The increase by self-division occurs in all these genera; this process is looked upon by Ehrenberg as one of the strongest and

most decisive characters of animal nature; but I have elsewhere proved, in the most satisfactory manner, that self-division is very common, both in the lowest plants as well as in the elementary organs of the more highly developed ones. The little vesicles endowed with molecular motion, seen in the genus *Euastrum* are completely identical with those observed in *Closterium* and the Conferva, and I see no good reason why *Closterium* should not be placed near *Euastrum.* The green corpuscles observed within the cells of most of the *Desmidiacea* are similar to the green corpuscles found in the cells of the Conferva; and though Ehrenberg may consider them as ova, I have observed their development in spores, and in several genera have distinctly seen that they contained amylum, and sometimes that they were even entirely composed of it.

"The second section of the *Bacillaria* includes the true *Bacillaria,* and are indicated by the term *Naviculacea;* here are to be found those numerous forms, which, from their occurrence in a fossil state, have lately given rise to such a great degree of interest, and which Ehrenberg, and many other naturalists, regard as undoubtedly belonging to the animal kingdom.

"The reasons adduced for such belief, however, are so weak, that the conclusions deduced from them are yet, for the most part, very doubtful.

"The movement of the *Bacillaria,* however free it may be, is by no means so free and active as that of the spores of the *Algae* and the spermatic animalcules, which are plants, or at least parts of plants, and the motion is no very positive ground for the belief of their animal condition. The common mode of propagation, seen in *Bacillaria,* is that of self-division, which is also proper to the cells of the higher plants; the increase by spores or ova ensues but rarely. The form, structure, and especially the habitus of the *Bacillaria* are evidently of that kind to lead one to consider them as plants; but the following circumstance, which is of very considerable interest, militates against it. In many *Naviculæ,* it is observed that the molecules, such as of indigo or carmine, &c., in the same solution, that may come into contact with the surface of the body of the creature, are immediately set in motion, and often run along with considerable rapidity by the side of the body, and even turn and run in an opposite direction.

This remarkable appearance has its cause, perhaps, in the existence of numerous delicate cilia, which are present over the surface of the creature, and giving rise to the motion.

"With our present instruments we cannot take cognizance of these organs; but when making use of a very high power, a sort of transparent narrow zone is observed around the bodies of the *Bacillaria.*

"Lastly, Ehrenberg adduces another observation as satisfactorily proving the animal nature of the *Bacillaria.* They sometimes receive colouring matter, which fills the vesicles looked upon by him as stomachs. This last statement appears at least very striking, but the way in which the case stands seems to be somewhat different. In the first place, I can see no stomach sacs in the *Naviculæ,* and never observed in the living and moving *Bacillaria* the colouring matter received at one extremity and carried towards the centre, where these stomach sacs should lie, whilst in the Infusoria such observations are easy; on the other hand, it is not rarely found, especially with the larger living animalcules, that the molecules of the colouring matter employed, lie upon the middle of the broad ventral surface, from which it appears as if the colouring material was really existing internally; but if a glass plate is placed upon it, and then properly removed, the globule of colouring matter may be taken away. The unprejudiced reader must then see that much observation is yet wanting ere we can hope satisfactorily to determine that the *Bacillaria* are truly animals; and how closely plants and animals border upon each other is recognizable in the spermatic animalcules of the lower plants, and the spermatic animalcules of animals." (Jahresbericht, Berlin, 1839.)

Since the date of Dr. Meyen's paper, much has been done to augment our knowledge of the *Bacillaria* , and, in the opinion of most naturalists, also to indicate yet more their affinity with plants.

The phenemenon of conjugation, so admirably investigated and illustrated by Mr. Thwaites, is regarded as particularly indicative of the vegetable nature of *Bacillaria.* In the *Desmidiacea,* the mode of conjugation is the counterpart of that in the *Zygnemeæ,* (a tribe of *Algæ),* producing a characteristic sporangium, but in the *Diatomacea,*

though the conjugation simply is analogous, yet the produced sporangia have no proper characteristics, as they resemble the fronds producing them, save in their larger dimensions. This variation, M. Thuret contends, renders the phenomena of conjugation indecisive of the vegetable character of the *Diatomeæ,* "for it is clearly not here a mode of *reproduction,*—it is only a second mode of *multiplication* of frustules, very curious, and very abnormal."

But a still more decisive objection to considering conjugation a proof of vegetable organization, is to be found in the recent discovery of Siebold, that that process is met with in the animal kingdom, and that he has witnessed it in *Diplozoon paradoxum,* and in *Actinophrys Sol:* the former an *Entozoon,* previously regarded as a single animal, but in fact a conjugated state of a Parasite, known as the *Diporpa;* the latter one of the Infusoria.

A third objection to the argument that conjugation is favourable to these organisms being *Algæ,* is that the higher kinds of *Algæ* do not conjugate, It would therefore follow if we consider them as *Algæ,* that the lower tribes of these plants require a renewal of the spermatic force, while the higher ones do not, which would be contrary to all our ideas of physiological laws.

The notion propounded by Ehrenberg, that the granules in the interior of *Bacillaria*—including the *Closterina,* are ova, has not met with support from the observations of other naturalists. In *Closterium* a circulation of the granular contents, involving also many of the stomach sacs of Ehrenberg, has been witnessed by most microscopists: and in one of the *Diatomeæ,* supposed to be a species of *Navicula,* Nägeli says, "I observed a pretty rapid circulation of the granular contents, the granules passing from the nucleus outwards along the edges, and back again to the former." (Ray Society, 1845. p. 221.)

The occurrence of this phenomena is adverse to the opinions of the internal animal organization, supposed by Ehrenberg; whilst it at the same time favours the hypothesis of the vegetable nature of these organisms, the circulation being similar to that so common in vegetable cells, and the circulating granules and vesicles, resembling those of various confervæ, and minute *Algæ.* (See Introduction to *Desmidiacea* and *Naviculacea.)*

The primary division of *Bacillaria*, adopted by Ehrenberg, and based on the circumstance of the presence or absence of a gelatinous induvium about or upon the true loricæ or frustules is faulty, inasmuch as this gelatinous envelope is met with in various *Desmidiacea* and *Naviculacea* in the adult state, and generally in all forms during the process of conjugation, as a temporary production. Where, however, the gelatinous mass plays a more important part, forms a nidus (matrix) for very numerous frustules, and is built up in a certain, definite manner, producing a characteristic *thallus*—expanded frond, it warrants the separation of such compound organisms from solitary, or merely concatenated forms, and their grouping together as a subsection.

The distribution of those *Bacillaria*, having a 'simple lorica,' into three groups, as made by Ehrenberg (see table page) is not generally followed: for most naturalists are indisposed to assign so high a distinctive value to the fact of the *attachment* of the loricæ, as is done by Ehrenberg, in the construction of the group *Echinellea*. Indeed the attachment of a frustule, or chain of frustules, appears inconstant, and several of the genera enumerated by Ehrenberg as free, subsequent observations have proved to occur also attached.

The prevailing plan is to make two sections, or families: viz., 1. *Desmidiacea* or *Desmidieæ*. 2. *Naviculacea;* the latter including the *Echinellea*, and the organisms with a double 'lorica' the *Lacernata* of Ehrenberg.

The *Naviculacea* are sometimes called, *Diatomacea*, *Diatomeæ*, and *Cymbelleæ*.

Mr. Harvey, in his Manual of British Marine Algæ, considers the *Diatomacea* and *Desmidiacea* as well marked sub-orders, or proper orders of a common alliance—the *Chlorospermeæ*, or green Algæ. Mr. Ralfs considers that the *Desmidieæ* can no longer be united with the *Diatomeæ* in one family—and gives the following distinctions: "The cell in the *Desmidieæ* consists of two valves united by a central suture, and, during division, the new formed portions are interposed between these valves. The *Desmidieæ* are membranous, or should a few species contain silica, it is not present in sufficient quantity to interfere with their flexibility. They rarely have acute angles, and are seldom (if ever) rectangular. They are often deeply incised or

lobed, warted or spinous. The internal matter is of a herbaceous green colour, and starch vesicles abound in the mature cell. They couple and form either orbicular or quadrate seed-like bodies, and are remarkable for the resistance which they oppose to decomposition.

"In all these respects they differ from *Diatomacea*. In the latter, each frustule consists of three pieces, one central and ring-like, or continuous all round; and the others lateral. The division is completed by the formation of new portions within the enlarged central piece, which then falls off, or else by a new septum arising at the centre; but I believe that, in every case, the separation commences internally before it extends to the covering. Their coverings, with very few exceptions, are siliceous, withstand the actions of fire and acids, and may be broken but not bent; the frustules are often rectangular in form, are never warted, and scarcely ever spinous. Their internal matter is usually brown when recent; and, although some species are greenish, or become green after they are gathered, none are of a truly herbaceous colour. Their vesicles bear some resemblance to those in the *Desmidieæ*, but they are of a yellower colour, and no starch has been detected in them. Some of them have been seen to conjugate, but their sporangia are elongated and in pairs, and the internal matter is similar to that of the frustules." (British Desmidieæ, page 20.)

In the following pages we have so far departed from Ehrenberg's arrangement as to include the *Closterina* with the *Desmidieæ*, in accordance with the now universally received views of their affinities. Moreover, we have excluded the appended and doubtful group, *Acineta*, according to the opinion of Ehrenberg himself, as expressed subsequently to the publication of his systematic work.

The particular details of the organization of the *Desmidiacea* and *Naviculacea*, are entered into at the commencement of each of those sections; those relating to the *Echinellea*, presenting nothing special, are represented in the account of the *Naviculacea*. Indeed, in our opinion, the section *Echinellea* should be merged, as is generally done in that of the *Naviculacea*, but, as we profess generally to follow the system of Ehrenberg, we have thought it right to retain it.

SECTION I.—DESMIDIACEA.

This is one of the sections into which Ehrenberg divides his great family *Bacillaria;* and it agrees mainly with the family *Desmidieæ* of other authors. Ehrenberg elevates the *Closteria* to the rank of a family,—taking position between *Vibrionia* and *Astasiæ*; which, however, in the systems of naturalists, have only the value of a genus. The alliance set up by Ehrenberg for the *Closteria,* is now considered untenable, whilst their affinity with *Desmidieæ* is as generally admitted. We feel ourselves therefore, warranted to depart so far from following Ehrenberg's arrangement, as to include *Closterium* among the genera of *Desmidieæ*; but have already given the characters of the family in its proper place. (See page 179.)

Recent researches, and more especially those of Mr. Ralfs, have so much added to our knowledge of these most beautiful organisms—the *Desmidieæ,* that much of Ehrenberg's account of them has become obselete, and cannot be put forward as a fair representation of the present state of science. This circumstance, coupled with that of the almost impossibility of engrafting the newly discovered genera and species into the system of Ehrenberg,—so greatly influenced as that is by his views of the animal organization of the *Desmidieæ,* has induced us to employ the systematic arrangement of those beings, as given by Mr. Ralfs, in his recent admirable Monograph on the "British Desmidieæ" it supplying, everything to be desired in presenting a concise view of this interesting group. We have freely employed the generic and specific descriptions of that able naturalist. To attempt an independent account, would imply a more intimate and perfect acquaintance with the *Desmidieæ,* than that possessed by one who has so successfully made them a special study. The present section may be consequently regarded as containing an epitome of Mr. Ralfs Monograph, although the researches of other naturalists are incorporated, and some new genera and species added.

Those who would acquire a complete knowledge of the *Desmidieæ,*

and who would work at them independently, should obtain Mr. Ralfs' book, in which every British species is described and figured, its special localities named, and many further details given, such as can be admitted only in a Monagraph.

Before entering upon the *Desmidiacea*, the reader will do well to examine the different drawings, illustrative of them given in Plate 1. f. 63 to 67; P. 2. f. 99 to 123; P. 13. f. 1 to 44; P. 18. f. 10 to 19.

"The *Desmidieæ* are of an herbaceous green colour; a few only of the *Closteria* have the rigid integument coloured, but in all, the internal matter is green. They inhabit fresh water.

Their most distinctive character is that "Each cell or joint, consists of two symmetrical valves or segments, and the suture or line of junction is in general well marked; in a few instances, however, as in *Scenedesmus*, it is determined principally by analogy. In *Pediastrum*, its situation is shewn by a more or less evident notch on the outer side, but no separation has been noticed. In the other genera the suture eventually opens and allows the escape of the contents, and it is indicated by either a transverse line or a pale band, and usually also by a constriction." An uninterrupted gradation may be traced from species in which these characters are inconspicuous to those in which they are fully developed:—from *Closterium*, in which there is no constriction to *Sphærozosma*, *Micrasterias*, and other genera, where the constriction is so deep that the segments appear like distinct cells, connected by a mere cord. By Ehrenberg, indeed, such forms were regarded as binate cells, but Mr. Ralfs for several reasons, concludes that each bipartite frond is a distinct, simple cell, merely constricted.

The *Desmideæ* multiplying by repeated tranverse division; the nature of which is well seen in the compressed and deeply constricted cells of *Euastrum*. Here, as the connecting portion is so small, and necessarily produces the new segments, which cannot arise from a broader base than its opening, these are at first very minute. "The segments are separated by the elongation of the connecting tube, which is converted into two roundish hyaline lobules. These lobules increase in size, acquire colour, and gradually put on the appearance of the old portions. Of course, as they increase, the

original segments are pushed further asunder, and at length are disconnected, each taking with it a new segment, to supply the place of that from which it has separated."

"It is curious to trace the development of the new portions. At first they are devoid of colour, and have much the appearance of condensed gelatine, but as they increase in size, the internal fluid acquires a green tint, at first very faint, but soon becoming darker; at length it assumes a granular state. At the same time the new segments increase in size, and obtain their normal figure; the covering in some species shows the presence of puncta or granules; and lastly, in *Xanthidium* and *Staurastrium*, the spines and processes make their appearance, beginning as mere tubercles, and then lengthening until they attain their perfect form and size; but complete separation often occurs before the whole process is completed. This singular process is repeated again and again, so that the older segments are united successively, as it were, with many generations. In *Sphærozosma* the same changes take place, but the cells continue linked together, and a filament is formed, which elongates more and more rapidly as the joints increase in number. This continued multiplication has its limits; the segments gradually enlarge whilst they divide, and at length the plant ceases to grow, the division of the cell is no longer repeated; the internal matter changes its appearance, increases in density, and contains starch granules, which soon become numerous; the reproductive granules are perfected, and the individual perishes. In a filament the two oldest segments are found at its opposite extremities; for so long as the joints divide they are necessarily separated further and further from each other. Whilst this process is in progress the filament in *Sphærozosma*, consists of segments of all sizes; but after it has reached maturity there is little inequality between them, except in some of the last formed segments which are permanently smaller. The case is the same with those genera, in which the separation of the cells is complete. It is obvious that, from the beginning, the new segment must have the same breadth as the junction from which it springs; and when consequently, the junction is as broad as the cell,—*i. e.* where the valves are united by their entire breadth, the new portion is of equal width, and so can be distinguished only by other means than their size."

"The spontaneous division of the frond is included by some writers amongst the modes of reproduction, but is rightly the manner only in which the individual plant grows, since all the cells arrive at maturity nearly at the same period, and terminate their existence about the same time." "The *Desmidieæ* are most probably reproduced only in two modes; one by the escape of the granular contents of the mature frond, and the other by the formation of sporangia, the result of the coupling of the cells."

When the cells approach maturity, molecular movements may be at times noticed in their contents, precisely like that seen in the Confervæ, and which has been aptly termed a *swarming*. When released by the opening of the suture, the granules still move, but more rapidly and to a greater distance. The subsequent history of these granules is, I conclude, similar to what has been traced in other Algæ. Compare with this the observations of M. Thuret, which we have appended to the account of *Pediastrum;* for in that genus M. Thuret states that he witnessed the escape of minute new fronds from the cells of the parent fronds.

On this supposed mode of propagation by Zoospores, we have the advantage of some recent remarks by the Rev. W. Smith: he writes, "another mode of increase, analogous to the propagation by Zoospores in *Spharoplea crispa* and other Algæ, has been assigned to the *Desmidieæ*, and it has been alleged that the endochrome escapes in the form of Zoospores, and becomes transformed into new fronds. M. Morren not only affirms this to be the case, but gives a figure illustrative of the conversion of these Zoospores, or as he terms them "*propagules*," into new fronds. Mr. Ralfs merely observes that the escape of the granular contents of the mature frond is *probably* one mode by which the *Desmidieæ* are increased. He, however, regards the "swarming of the granules" (which I am disposed to regard as a disturbance attendant upon the decay of the granular mass) as identical with the movement of the Zoospores; and states that with the history of these granules after their escape, he was altogether unacquainted. He afterwards gives a figure (British Desmidieæ, P. 27), upon the authority of Mr. Jenner, representing the bursting of the sporanguim and the growth of the young fronds from its contents in *Closterium acerosium*, so closely resembling the figure by

M. Morren (see P. 18, f. 15) of the conversion of the propagules of C. Ehrenbergii into young fronds, that I cannot but believe a similar phenomenon to have been noticed by both observers, and am inclined to accept the views of Mr. Jenner as the correct one, and to regard propagation by Zoospores or "propagules" as one not yet satisfactorily established in the *Desmidieæ*." (Ann. Nat. Hist. 1850, p. 4.)

"The second mode of reproduction is by coupling (*conjugation*), and the formation of sporangia. A communication is established between two cells, and a seed-like mass is formed in the same manner as in the *Conjugatæ*. (See P. 13, figs. 5, 6, and 15.) This is green and granular at first, but soon becomes of a homogeneous appearance, and of a brown or even reddish colour. In the family *Conjugatæ*, the cells conjugate whilst still forming parts of a filament; but in the *Desmidieæ*, the filamentous species almost invariably separate into single joints before their conjugation, and, in most of the species, the valves of the cells become detached after they are emptied of their contents. (See the account of *Closterium*.) In many genera the sporangia remain smooth and unaltered; in others they become granulated, tuberculated, or spinous; the spines being either simple or forked at the apex. The sporangia I consider capsules; and this view seems to be confirmed by the experience of Mr. Jenner, who states that the covering of the sporangium swells; and a mucus is secreted, in which minute fronds appear, and, by their increase, at length rupture the attenuated covering. The sporangia are most abundant in spring before the pools dry up.

"That the orbicular spinous bodies, so frequent in flint, are fossil sporangia, cannot be doubtful, when they are compared with figures of recent ones. Ehrenberg describes them as fossil *Xanthidia*; but the true *Xanthidia* have compressed, bipartite, and bivalved cells, whilst these fossils have globose and entire ones. In all the *Desmidieæ*, but especially in *Closterium* and *Micrasterias*, small compact seed-like bodies of a blackish colour are at times met with. Their situation is uncertain, and their number varies from one to four. In their immediate neighbourhood, the endochrome is wanting, as if it had been required to form them, but in the rest of the frond it retains its usual colour and appearance. I cannot satisfy myself respecting the nature of these bodies, but I believe them

either to arise from an unhealthy condition of the plant, or else to be parasitic.

"All the *Desmidieæ* are gelatinous. In some the mucus is condensed into a distinct and well defined hyaline sheath or covering, as in *Didymoprium Grevillii*, and *Staurastrum tumidum;* in others it is more attenuated, and the fact that it forms a covering, is discerned only by its preventing the contact of the coloured cells. In general, its quantity is merely sufficient to hold the fronds together in a kind of filmy cloud, which is dispersed by the slightest touch. When they are left exposed by the evaporation of the water, this mucus becomes denser, and is apparently secreted in larger quantities to protect them from the effects of drought.

"Besides the movement of the granules spoken of, a circulation, or rather a rotation of the contents of the cells of *Desmidieæ* may occasionally be seen under a careful adjustment of the microscope," (See p. 180.) Mr. Ralfs has witnessed it in *Closterium Lunula*, and in *Penium Digitus*. He says, "It seems, at least in the *Closterium*, to be restricted to the space between the mass of endochrome and the integument; for neither Mr. Bowerbank nor myself could detect it in the internal parts of the endochrome. The movement, however, extends over the whole surface of the endochrome. The circulation being carried on between the integument, and the mass of endochrome, which is usually brought full into view by the observer, explains the difficulty experienced in detecting the circulation, except at the margins. The motion was very irregular: the fluid flowed at one time towards the extremities, and at another in the opposite direction, and the intervals between these changes were of uncertain duration. Streams, also, though apparently not separated by any partitions, flowed side by side in contrary directions. The currents evidently consisted of an homogeneous fluid; but, from time to time, minute granules were detached from the internal mass of endochrome, and carried along in the streams for short periods, after which they either returned to the quiescent portion, or passed into other currents. It seems to deserve particular notice, that the circulation was not interrupted at the suture. The process in *Penium Digitus* was somewhat different from that just described."

Nägeli believes in the presence of a nucleus in the *Desmidieæ*,

generally. He says, "*Arthrodesmus* possesses a small colourless corpuscle on the wall of the cell, which looks like a nucleolus. *Euastrum* frequently exhibits, among the green contents, two obscure bodies resembling nuclei, always one in each half, when the division through the middle takes place. These are not attached to the cell-membrane, but lie free in the midst of the cavity; they appear to possess a dark centre (nucleolus?) and a clear periphery (enveloping-layer?) . . . . In *Closterium*, a nucleus lies in the centre, which possesses a thick whitish nucleolus within a clear enveloping layer. It is coloured brown by iodine, and wholly resembles the nucleus in *Spirogyra*." Ehrenberg, who previously noticed these nuclei considers them analogous to fecundating glands. Both naturalists agree as to their probable function, but each gives an explanation as they view them, either as plants or as animals.

Respecting the nature of the *Desmidieæ*, Mr. Ralfs affirms that they have as strong a claim as the *Conjugatæ* or *Palmellæ* can have, to rank with the Algæ. On the other hand, he considers the proper station of the *Diatomaceæ* very doubtful.

Ehrenberg's reasons for placing the *Desmidieæ* in the animal kingdom are the following:—That they exert a voluntary motion; that they increase by transverse self-division; and that the *Closteria* have at their extremities apertures, and protruding organs, continually in motion. Although two of these reasons apply only to the genus *Closterium*, Mr. Ralfs will admit that if the *Closteria* can be proved animals, the questions as to the other genera will be decided. As to the possession of *voluntary* motion, he protests against the use of the word voluntary as prejudging the question. That the *Desmidieæ* move, must be admitted; but, whilst making this admission, he maintains that in the lower tribes of organic life, motion is not an indubitable sign of an animal nature. Indeed, Mr. Ralfs and Mr. Jenner, have both failed to perceive any actual movement: (see *Closterina* p. 179), and whatever may be the motive power of the *Desmidieæ*, according to those observers, they possess it only in common with acknowledged Algæ, and in a less degree than either the *Diatomeæ*, the *Oscillatoriæ*, the sporules of various Algæ, or indeed their own sporules. Ehrenberg considers, that increase by voluntary division, is the character which separates animals from

vegetables, and adduces no other reason for his denial of the vegetable nature of some genera; but the bisection of cells is very frequent, if not universal, in the more simple Algæ; and Mr. Ralfs is of opinion that the process is identical with that witnessed in the *Desmidieæ.*

"I (says Mr. Ralfs) am not in a position either to deny, or to affirm, with confidence, the presence of openings in the extremities of the *Closteria.* It appears to me, indeed, that in *Closterium,* there is a slight notch, or more usually the rudiment of one, at the apex of the segments,—a mere indication in short of what is fully developed in *Tetmemorus* and *Euastrum.* In no instance, can any portion of the contents of the cell be forced out from the extremities. On this subject, the views of Ehrenberg, and Mr. Dalrymple, are given at page 180. Mr. Ralfs has the following remarks upon them.

"I confess I am unable to refer to any example in other Algæ of terminal globules, like those present in the *Closteria,* but neither can one be found amongst animals; and if in some respects they have an analogy with organs belonging to the latter, in others they agree better with vegetable life. The contained granules seem to me to differ in no respect, except in position and uninterrupted motion, from other granules in the same frond, and, as I have already stated, I once saw the motion continue after their escape from the cell, precisely as in other zoospores. Meyen observes that the functions of these bodies are very difficult to determine, but they are to be found in very many Confervæ, and are perhaps to be likened to the spermatic animalcules of plants.

"The contraction of the internal membrane of the *Closteria,* or the expulsion of their contents on the application of iodine or other re-agents, cannot be relied upon as a satisfactory test for determining their nature, for the blandest fluids will, in some cases, occasion violent action. From the experiments of Mr. P. Grant, it seems that the re-action of a re-agent cannot be predicated with any certainty, and that the molecular action is not affected by several strong poisons, whilst it yields to other substances less generally deleterious.

"With regard to the "supposed ova," I fully agree with Meyen, that they are similar to the green corpuscles found in the cells of

Confervæ; and the fact of their containing amylum (starch) is decisive against the notion that they are eggs.

"Although at first sight it seems to indicate the contrary, the swarming of the zoospores or granules really affords a strong confirmation of the vegetable nature of the *Desmidieæ.* The same phenomenon is very generally observed in the Algæ, but no similar motion has ever been witnessed in the contents of an animal after their escape.

"The presence of starch, first observed by Meyen, seems now generally admitted. Mr. Dalrymple, who at first failed to detect it in *Closteria*, afterwards did so in *Penium Digitus:* and Dr. Bailey, of New York, has repeatedly proved its presence in *Closterium Trabecula,* as well as in other species. Mr. Ralfs has repeatedly noted the effects of iodine on many of the *Desmidieæ;* but has found the presence of starch indicated only when granules (the ova of Ehrenberg) were present, as the fluid colouring matter always becomes brownish. Precisely similar results followed the application of iodine in *Conjugata* in different stages of growth. In the young cell there is no starch, but after its first appearance it continues to increase, and is most plentiful in the sporangium. Of all the facts which indicate the vegetable nature of the *Desmidieæ,* the presence of starch is undoubtedly the most important, since it is the most easily subjected to the test of experiment.

"The conjugation of the fronds in this family supplies an equally striking fact in proof that it belongs to the vegetable kingdom.

"As in the *Conjugata* and other Algæ, so in the *Desmidieæ,* a bag or cell forms between two individuals, the entire contents of which pass out and unite together to form one reproductive body, which, becoming detached, leaves the parent corpuscles altogether empty. (See P. 18. figs. 10 to 19.) Such an occurrence is, I believe, not only unknown amongst animals, but is contrary to all our notions of animal propagation. The *Desmidieæ*, moreover, present the several variations of form of sporangia, met with in different genera of Algæ.

"That the *Desmidieæ* resist decomposition, exhale oxygen on exposure to the sun, preserve the purity of water containing them, and, when burnt, do not emit the peculiar odour so characteristic of

animal combustion, are other facts respecting this family, which, taken singly, might have less value, but in their combination furnish a most important support to the arguments already adduced.

"The *Desmidieæ* I regard then as Algæ, allied on the one side to *Conjugatæ*, by similarity of reproduction, and on the other to the *Palmelleæ*, by the usually complete transverse division, and by the presence of gelatine. Indeed, the relation to the latter is so intimate, that it is difficult to say to which family some genera belong:—Some species of *Scenedesmus* may be allowed to have an almost equal claim to rank with either."

An additional exemplification of the affinity of the *Desmidieæ* with the Algæ, has been recently afforded by detection by Mr. Jenner, confirmed by Mr. Ralfs, in a species of *Tyndaridea*, of evident, though faint, longitudinal striæ, similar to those in many *Closteria*. Mr. Bowerbank has also pointed out the same appearance in *Tiresias*.

Owing no doubt to the soft, or but slightly siliceous integument of the *Desmidieæ*, but few forms have been found in a fossil state, among such are some species of *Closterium* and *Euastrum*, and doubtful specimens of *Xanthidium*.

In Ehrenberg's system the *Desmidieæ* formed one division of his family *Bacillaria*, the characters of which, are given in the table, at page 221.

The following genera have been established since this table appeared: namely—*Lithodesmium*, *Eucampia*, *Asterodictyon*, *Monactinus*, *Gymnozyga*, *Hyalotheca*, *Polysolenia*, and *Zygoxanthium*. The genus *Hyalotheca* is adopted by Mr. Ralfs; of *Eucampia* and *Lithodesmium* we have figures; but the other genera are known to us only by name, or by imperfect descriptions.

Genus Hyalotheca, (Ehr.)—Filaments elongated, cylindrical, very gelatinous; *joints* having either a slight constriction, which produces a crenate appearance, or a grooved rim at one end which forms a bifid projection on each side. *End view* circular.

The filaments are invested with a broad gelatinous sheath; are very fragile in one species, but not so in the other. The cylindrical filament distinguishes this genus from *Desmidium* and *Sphærozosma*. It has no angular projections, is not twisted, and has always the

same apparent breadth, and consequently, in all these respects, differs from *Didymoprium.*

Hyalotheca *dissiliens* = *Conferva dissiliens,* (Smith.)—Filament fragile, crenate; a shallow groove round each joint, dividing the endochrome into two portions. The transverse view is circular, and shows a mucous border of the same form. In this aspect too, the endochrome is generally disposed in a stellate manner, with six or seven rays, and frequently has a colourless central spot. This plant is very fragile, breaking into single joints, each with a perfect mucous covering. Conjugation takes place by tubes: sporangia, circular. (P. 13. f. 32. 35.; f. 32 a transverse view.)

H. *mucosa* (Ehr.)—Filament scarcely fragile; joints not constricted, but having at one of the ends a minute bidentate projection on each margin, the adjoining end of the next joint being similar. The filaments have a very broad mucous sheath. The joints seem to be in pairs; a single one is consequently asymmetrical.

H. *dubia.* (Kützing.)—Filament without a mucous tube; joints rather broader than long, with two puncta near each margin.

H. *cylindrica.* (Ehr.) = *Desmidium cylindricum,* (Greville and de Brébisson, 1835.) See *Didymoprium Grevillii.*

Genus Didymoprium.—Filaments elongated, gelatinous, fragile, regularly twisted cylindrical, with a bidentate process or angle on each side of the joints; hence the margins of the filament are crenate.

The twisting of the filament causes it to appear of unequal breadth, and the form of its joints to vary according as more or less of the angles is seen at the margin. In a transverse view the joints are circular or broadly elliptic, with two minute opposite projections, formed by the angles. The endochrome is radiate; its rays from four to seven. (P. 13. f. 38.)

Didymoprium differs from *Desmidium* in having only two angles. In a transverse view, the latter presents a cell truly angular, irrespective of the bidentate projections, and an endochrome divided into a number of rays corresponding with the number of angles; neither of these circumstances occur in *Didymoprium.*

The filaments of this genus increase in length, by the repeated division of the joints, exactly as in the other genera, the new portions

being formed between the original segments, which in other respects remain unaltered.

Didymoprium *Grevillii.*=*Hyalotheca cylindrica.* (Ehr.)—Sheath distinct; joints of the filament broader than long, with a thickened border at their junction; transverse view broadly elliptic. The sheath is jointed as well as the filaments.

In conjugating, it separates into single joints: the joints or cells become connected by a narrow process, often remarkable for its length, and the contents of one cell pass through it into the other, and a sporangium is formed in the same manner as in many of the *Conjugatæ*.

The transfer of the endochrome takes place in a mass. After the completion of the process, the empty cell is frequently detached, as also occurs in those *Conjugatæ* which bear the sporangium within the cell.

In a front view, the sporangium is as orbicular as the quadrate form of the joint will permit. The mucous covering remains unaltered on the joints when they are coupled.

D. *Borreri.*—Joints inflated, barrel-shaped, longer than broad; transverse view circular. Filaments pale green, very slender, their mucous sheath wanting or indistinct; angles of joints bi-crenate. On account of the length of the joints, the disposition of the endochrome in two portions is very distinct. The joints have not a thickened border as in *D. Grevellii*, and the filament separates with less facility into single joints. (P. 13, f. 38, 39; fig. 38 a transverse view). The sporangium is elliptic and lies between the cells which remain attached to it.

Kützing suggests that this plant may be identical with the *Gymnozyga moniliformis*, of Ehrenberg.

Genus Desmidium.—Filament fragile, elongated, triangular or quadrangular, regularly twisted; joints bidentate at the angles. This organism is of a pale green colour and slightly opaque; when dried, the British species usually acquire a yellowish appearance, and adhere to paper or talc less firmly than plants belonging to allied genera. The filaments are regularly twisted, but being triangular or quadrangular, two of the bidentate angles of each joint are always visible at the

margins. The endochrome is divided into linear portions by a pale transverse line between the angles. Traces of a mucous sheath may be detected. A transverse view shows that the endochrome has thick rays corresponding in number with the angles; these rays are frequently cloven.

Recent specimens are known from other genera by one or two dark waved lines passing down the filament, caused by the twisting of the angular filament.

Desmidium *Swartzii.*—Triangular, equal, with a single longitudinal, waved, dark line, formed by the third angle; end view triangular, with the endochrome three-rayed. Filaments very fragile; adhere but slightly to paper; twisted. The joints are, in the front view, somewhat quadrangular, broader than long, and each angle has two minute, slightly angular teeth. The joints are connected by a thickened margin, which partly fills the notch formed between them by the projection of their angles, whence the chain has a pinnatifid appearance; transverse view, triangular; angles blunt, and sides slightly concave. The segments contain numerous minute granules. Length of joint 1-2000th to 1-1666th. Breadth of filament 1-633rd.

D. *quadrangulatum*, (Ralf.) — Quadrangular, varying in breadth from the twisting of the filament, and having two longitudinal waved lines; the end view quadrangular, with the endochrome four-rayed. Being quadrilateral, the filament presents two longitudinal lines crossing each other obliquely. (P. 13, figs. 37 and 40; f. 40 a transverse view.) Length of joint 1-1244th.

D. *undulatum*.—Joints with four crenatures at each margin.

The constriction of the joints is marked by slight marginal notches, on each side of which are two broad crenatures; in this respect D. *undulatum* differs from D. *Swartzii*.

D. *didymum* (Corda.)—Ehrenberg and Meneghini unite D. *didymum* to D. *bifidum* (Ehr.) which the latter describes as a filamentous plant. In D. *bifidum*, says Corda, there are but two simple projections on each margin of a segment, but in D. *didymum*, the two projections themselves present each, two secondary ones.

D. *bifidum* (Ehr.) = *Staurastrum bifidum* (Ralfs.)

D. *orbiculare* (Ehr.) = *Staurastrum orbiculare* (Ralfs.)

D. *hexaceros* (Ehr.) = *Staurastrum tricorne* (Ralfs.)

DESMIDIUM *aculeatum* (Ehr.) = *Staurastrum aculeatum* (Ralfs.)

D. *apiculosum* (Ehr.) = *Staurastrum muricatum* (Ralfs.)

In a paper published by Ehrenberg in 1840, we have found the following described as species of *Desmidium*, but the characters detailed, lead us to the opinion that they really belong to *Staurastrum*. One of them, indeed, called *Desmidium ramosum*, has, we observe, been identified by Mr. Ralfs as equivalent to his *Staurastrum spongiosum*. The others are :—

D. *divergens* (Ehr.)—Angles of the sides aculeate, recurved on one side, corpuscles binate, divergent; semilunar on the dorsum; surface smooth. Diameter 1-1150th. If a representative of a new genus?

D. *tridens*.—Angles on the sides acute, long, rostrate, tridentate at the apex; fusiform dorsally; the entire surface of the centre of the disc armed with spines. Diameter 1-480th. Is allied to D. *hexaceros* (Ehr.)

Genus APTOGONUM (Ralfs.) — "Filament elongated, triangular or plane; joints bicrenate at the margins; an oval foramen between the joints. Endochrome bipartite.—It is closely allied to *Desmidium*, but the large oval foramen between the joints is so remarkable a character, that I must concur with Ehrenberg in placing it in a separate genus. As, however, Ehrenberg's name, *Odontella*, had previously been given by Agardh to some *Diatomaceæ*, it became necessary to find another name. Ehrenberg included *Sphærozosma* in his *Odontella*, but the present genus is essentially distinct from *Sphærozosma*; the latter has the joints incised or sinuated, and gland-like processes at their junctions, and it is merely by the interposition of these processes that the joints are now and then slightly separated; in this genus, on the contrary, the joints have two prominent teeth at the margins or angles, and the foramen results from the excavation or concavity of the joint itself, and not from the presence of glands.

A. *Desmidium* = *Odontella Desmidium* (Ehr.)—Joints in the front view quadrangular, broader than long; crenatures distinct. No sheath.

Var. (*a*.)—Filaments triangular, regularly twisted; crenatures rounded.

Var. (*b.*)—Filaments plane; crenatures shallower and slightly angular. (P. 2. f. 108.)

APTOGONUM *Baileyi.*—Filament not crenated; joints about equal in length and breadth. Filament triangular; angles, in end view, rounded.

Genus SPHÆROZOSMA (Corda.)—Filament plane, fragile; joints closely united by means of glandular processes, and deeply divided on each side, thus forming two segments, and giving a pinnatifid appearance to the filament. Filaments pale green, gelatinous, probably not twisted. Transverse view linear or oblong. This genus differs from *Desmidium*, *Didymoprium*, and *Hyalotheca*, in its flat filaments (not twisted), in the deep division of the joints into segments, and especially in the presence of the minute gland-like processes at the junction of the joints. On account of its deeply constricted joints, this genus forms a connecting link between the preceding and the following genera.

S. *vertebratum* = (*Odontella* (?) *unindentata*, Ehr.)—Joints as broad as long, deeply divided into two segments by a narrow notch on each side; junction glands oblique, solitary at the centre of each margin. It is furnished with a broad, colourless, and very delicate mucous sheath. (P. 2. f. 107.) Length 1-1429th.

S. *excavatum.*—Joints longer than broad, having a deep sinus on each side, and two sessile glands on each margin at their junction. Filament minute, fragile. The sporangium is formed between the conjugating joints, and is elliptical in figure.

S. *lamelliferum* (Corda.)—Filaments short; nearly uniform; joints divided by a transverse line to one-third of their depth, segments rounded.

S. *pulchrum* (Bailey.)—Joints twice as broad as long, deeply incised on each side; junction-margins straight, connected by short bands. It is twice as large as S. *vertebratum.*

S. *filiforme* = *Odontella* (?) *filiformis* and *Tessarthra filiformis* (Ehr.)—Joints bilobed, united by double slender processes, which enclose a quadrate foramen between each pair.

S. *serratum* (Bailey.)—Joints broader than long, deeply notched or divided into two transverse portions, with acute projecting ends,

which give a serrated outline to the chain. Common in fresh water in South Carolina, Georgia, and Florida.

Genus MICRASTERIAS (Ag.) — Frond simple, (binate only when dividing), deeply divided into two, lobed segments; the lobes inciso dentate, (rarely only bidentate), and generally radiant.

In two species sporangia have been detected; they are large, globular, and furnished with short spines, which at first are simple, but subsequently branched at the apex. In the perfect state they are particularly interesting from their resemblance to the fossil "*Xanthidia,*" of Ehrenberg and others.

The orbicular, plane, and deeply incised fronds will distinguish *Micrasterias* from all other genera in this family. In *Euastrum,* the only one with which it can be compounded, the fronds are oblong, and the lobes are not incised.

This genus is not equivalent to the one so named by Ehrenberg. (See the genus *Pediastrum.*)

* *Frond circular; segments five-lobed; lobes approximate, the end lobe narrow.*

M. *denticulata.*=*Euastrum Rota,* (Ehr.)—Large, orbicular, smooth; lobes cuneate, dichotomously divided, the ultimate sub-divisions truncate-emarginate with rounded angles; the end lobe, the narrowest, is simply emarginate. (P. 2 f. 121, 122, 123, and Sporangium, P. 13, f. 22.)

The process of conjugation appears similar to what takes place in *Staurastrum dejectum;* the contents of both fronds unite, and form a globular sporangium enclosed in a fine membrane, and its surface gradually acquires scattered, stout, elongated spines, at first simple, with their apex obtuse, but afterwards forked or trifid; and, finally, further branched, and frequently more or less re-curved. The sporangia are of considerable size,—a necessary consequence of the union of the contents of both fronds. (P. 13, f. 22.)

The truncate ends of the sub-divisions distinguish this species from *M. rotata.* Length 1-113th.

M. *rotata.*—Orbicular, smooth; lobes dichotomously incised, ultimate sub-divisions bidentate. It differs from *M. denticulata,* in having the ultimate self-divisions dentate. Length 1-91th. Breadth 1-104th.

MICRASTERIAS *fimbriata.*—Orbicular, smooth; lobes dichotomously incised, ultimate sub-divisions obtusely emarginate, spinoso-mucronate. Length 1-108th. Breadth 1-119th.

M. *radiosa* = *Euastrum Sol.* (Ehr.) — Orbicular, smooth; lobes dichotomously divided; ultimate sub-divisions inflated, attenuated at the end, bidentate or mucronate. Differs from *M. rotata* in its inflated sub-divisions. Length 1-138th. Breadth 1-138th.

M. *papillifera.* — Orbicular, with marginal gland-like teeth; segments five-lobed; lobes dichotomously incised; the principal sinuses bordered by a row of minute granules. Sporangia similar to those of *M. denticulata*, but smaller. Endochrome brownish green. Length 1-221th. to 1-205th. Breadth 1-238th. to 1-211th.

* * *Frond subelliptic; segments three or five-lobed; lobes radiant, the end one somewhat exserted and divergent.*

M. *furcata.*—Segments five-lobed; lobes bifid; their divisions linear, divergent, and forked at the apex. Frond smaller than that of M. *rotata;* its outline broadly elliptic, sometimes almost circular. Endochrome green. Length 1-135th. Breadth 1-156th. Very rare.

M. *crux-melitensis* = *Euastrum crux-melitensis.* (Ehr.)—Frond rotundato elliptic; segments sub-five-lobed; lobes bifid, sub-divisions short, stout and bidentate at the apex. Size same as *M. furcata,* and similarly divided. Empty fronds very delicately punctated. Length 1-200th. Breadth 1-221th. Very rare. (P. 2. f. 124.)

M. *americana.* = *Euastrum. Americanum.* (Ehr.)—Angular elliptic; segments three-lobed, end lobe with bipartite angles; lateral lobes broad, margin concave, inciso-serrate. (P. 13. f. 44.)

Var. (*a.*)—Serratures distinct.

Var. (*b.*)—Serratures obscure. Length 1-204th. Breadth 1-254th. Rare.

*** *Fronds orbicular; segments obscurely five-lobed; the end one broadest.*

M. *truncata.* = *Euastrum Rota.* (Ehr.) — Orbicular, segments with five-shallow lobes, the end one very broad, truncated; lateral ones inciso-dentate. Length 1-240th. Breadth 1-250th.

M. *crenata* differs from *M. truncata* in the convex margin of its end lobes, and the absence of teeth on the lateral ones. Length 1-244th. Breadth 1-263rd.

* * * * *Fronds oblong.*

MICRASTERIAS *Jenneri.*—Oblong, minutely granulated; segments five-lobed; lobes closely approximate, cuneate; lateral ones obscurely bipartite, sub-divisions emarginate. Transverse view fusiform. (*A.*) granules appearing like mere puncta; (*B*) granules larger, giving a dentate appearance to the margin.

This species seems to unite *Micrasterias* with *Euastrum.* It agrees with the latter genus in figure, but the lobes have inconspicuous incisions, which divide them into two portions, each slightly emarginate. A transverse view shews the absence of the protuberances always found in true species of *Euastrum.* Length 1-147th. Breadth 1-209th.

* * * * * *Lobes horizontal, attenuated, bidentate.*

M. *oscitans.*—Smooth, with convex ends; segments constricted; lobes horizontal, conical, bidentate. Transverse view fusiform. Length 1-156th. Breadth 1-211th. (P. 13, f. 28, 29.)

M. *pinnatifida.*—Minute, plane, its ends straight; segments deeply constricted; lobes horizontal, triangular, bidentate; resembles *M. oscitans* in form, but its surface is flatter, the end margin straight or slightly concave instead of convex, and the lobes more tapering. Length 1-440th. Breadth 1-392nd.

M. *apiculata* = *Euastrum apiculatum,* (Ehr.)—Orbicular, rough, with scattered spines; segments five-lobed, lobes incised and toothed, and lobe narrow.

M. *quadragies-cuspidata.*—Has scattered hair-like spines; end lobe the broadest.

M. *foliacea* (Bailey).—Sub-quadrate; end lobes narrow, with emarginate angles; lateral lobes inciso-dentate, with a short, rounded tooth-like projection next the end lobe.

M. *Torreyi.* (Bailey.)—Orbicular; lateral lobes deeply incised; inner sub-divisions acute; external, bidentate at the apex; all tapering. End lobe narrow and not exserted.

M. *muricata.*—Segments divided by deep indentations into three transverse portions; the basal with three, the others with two linear processes on each side.

M. *muricata* differs remarkably from *M. furcata* and every other known species. The division into five lobes is indicated merely

by the presence of processes, which, unlike those in the other species, do not diverge in the front view, but spread laterally, in such a manner, that the one nearest the eye, more or less conceals its companions.

MICRASTERIAS *Baileyi.*—Granulated; segment three-lobed; lobes bipartite, end one much exserted; all the sub-divisions bidentate at the apex.

M. *incisa* = *Euastrum crux-melitennis,* (Ehr.)—Lobes horizontal, basal ones truncate, with a tooth at each angle; end lobe convex, its angles acute.

The following new species are found in the Southern States of America, and were discovered by Dr. Bailey of New York in 1850.

M. *arcuata,* (B.)—Quadrangular segments three-lobed, the basal lobes long and arcuate, subtended by the transverse projections from the ends of the slightly notched terminal lobes. An interesting and very distinct species, which can be confounded with no other except the following. Lakes in Florida.

M. *expansa,* (B.)—Segments three-lobed, basal lobes long, sub-conical, acute; terminal lobes slender, forked at the end, with the divisions much shorter than the basal lobes. This somewhat resembles the preceding species with which it occurs, but I have seen no intermediate forms, out of many hundreds of each, and the characters above given appear sufficient to separate them.

M. *quadrata,* (B.)—Large, quadrangular, 3-lobed, basal lobes elongated, slightly curved, bidentate; terminal lobes with two slender transverse bidentate projections. Its larger size, and distinctly bidentate projections, sufficiently distinguish it from the two preceding species.

M. *ringens,* (B.)—Oblong, segments three-lobed, coarsely granulated near the edge; basal lobes sub-divided by a deep notch into two, rather broad and obtuse, or slightly bidentate projections; terminal lobes exserted, emarginate; extremities bidentate or obtuse. Resembles *M. Baileyi*, but is larger, divisions less slender, and with the granulations differently placed.

Genus EUASTRUM.—Frond simple, compressed, deeply divided into two segments which are emarginate at their ends, lobed or sinuated, generally pyramidal and furnished with circular inflations.

In *Euastrum,* Ehrenberg includes *Micrasteaias* (Agardh.) not *Micrasterias,* (Ehr.) and *Cosmarium; Euastrum* agrees with *Micras-*

terias in having lobes and emarginate ends, but the lobes are not incised, nor do they radiate from the centre, and the inflated projections will distinguish it not only from *Micrasterias*, but from every other genus in the family. From *Cosmarium* it differs also in the lobed and emarginate segments.

Ehrenberg's characters of this genus *Euastrum*, or *star-disked Animalcules* are—members free, inclosed in a simple compressed lorica, composed of only one piece, and by their adhering in pairs, which are disposed in the form of a two-lobed disc or table. Whether a lobe can be regarded, separately from its companion, as a distinct organism, is not determined, but by cutting or destroying the one, the other empties itself at the same time, although the lorica appears detached in the middle. No openings have been seen in the ends, as in *Micrasterias*, but it is probable such exist in the middle, where they are connected. The lorica is membranous, firm, colourless, and combustible; it contains the hyaline and contractile body of the animalcule, filled with green granules. Its propagation by self-division is peculiar and highly interesting. (See f. 123.) The middle elongates, and from it two new segments are formed, one uniting and forming the companion to one of the old ones, and the other producing the same with the remaining old one, when the newly-formed individuals separate, and two pairs are the result. From this method of self-division, specimens having unequal lobes, are produced by any accidental rupture, before the new ones in the middle are fully developed. All the species are found among conferva.

Mr. Ralfs divides this genus into three sections.

1. *Segments of the frond deeply lobed; terminal lobe cuneate, and partly included in a notch formed by the projection of the lateral lobes.*

Euastrum *verrucosum* (Ehr.)—Frond rough with conic granules; segments three-lobed; lobes broadly cuneate with a broad shallow notch. Transverse view oblong, with three inflations at each side, and a smaller one at each end. It is known by the conic granules giving a dentate appearance to the outline. Length 1-267th. Breadth 1-270th. (P. 2. f. 125.)

E. oblongum = (E. *pecten*, Ehr.)—Smooth, oblong; segments five-lobed; lobes cuneate, emarginate, the terminal one partly included between the lateral ones. Empty fronds punctate. Sporangia orbi-

cular, with numerous conic tubercles. Length 1-156th. Breadth 1-282nd. Transverse view three times longer than broad, with three rather distant inflations or lobes on each side, and one at each end.

EUASTRUM *crassum.*—Smooth; segments three-lobed, subquadrilateral; terminal lobe cuneate, partly included in a notch formed by the lateral lobes. Transverse view with three lobes on each side, and one at each end. Empty frond punctate.

Var. (*b.*)—Smaller, sides more concave; base more inflated; and the angles including the terminal lobe more elongated. Length 1-193rd to 1-132nd. Breadth 1-263rd. to 1-260th.

2. *Segments sinuated; terminal lobe exserted, and united with the basal portion by a distinct neck.*

E. *pinnatum.*—Five lobed; end lobe exserted, dilated; upper margin of lobes horizontal. Basal lobes emarginate; the intermediate ones smaller and entire. Empty frond punctate. Length 1-888th. Greatest breadth at basal lobes 1-454th.

E. *humerosum.*—Smooth, terminal lobes dilated; emarginate; neck partly included between the elongated middle lobes, which resemble processes; basal lobes emarginate. Empty frond minutely dotted. Transverse view has three lobes on each side, and one at each end; whence it differs from E. *affine.* It is distinguished from all other species in this section by its included neck. Length 1-225th. Breadth 1-382rd.

E. *affine.*—Three-lobed, with intermediate tubercles; lobes emarginate, end one dilated, its notch linear. Transverse view with four lobes on each side. Empty frond punctate.

E. *ampullaceum* is best recognized by its short segments, in which, and its broad inflated base, it differs from E. *affine;* whilst the distinctly dilated terminal lobe separates it from E. *didelta.* Empty frond punctate. Length 1-274th.

E. *insigne.*—End view cruciform. Empty frond punctate. The transverse view differs from that of every other species in being contracted at the middle. The inflated base and slender neck, conjoined with its dilated end, are sufficiently characteristic. Length 1-232nd.

E. *didelta.*—Segments with inflated base, intermediate tubercles, and notched, and scarcely dilated end; transverse view, four shallow lobes on each side, and one at each end. Segments pyramidal;

neck broad. End view bilobed. Empty frond punctate. Sporangia orbicular, with subulate spines. Length 1-185th.

Euastrum *ansatum* (Ehr.)—Segments inflated at the base, and tapering upwards to the notched but not dilated extremity ; transverse view cruciform. The end view has two circular and entire lobes. Empty frond punctate. Length 1-315th.

E. *circulare.*—Segments three-lobed, mostly with five basal tubercles ; four of them usually disposed semi-circularly about the fifth; end notched, scarcely dilated. Length 1-320th.

E. *pectinatum.* — Segments three-lobed; terminal lobe dilated, scarcely emarginate; lateral lobes emarginate, horizontal; end view two-lobed at each end, and two lobules on each side. Neck short and broad. (P. 13. f. 10.) Empty frond punctate. It differs from all the preceding, in the absence of a terminal notch, in the lobules of the end lobe, and in having the ends emarginate in the transverse view. Sporangia orbicular with conical tubercles, or short obtuse spines. (P. 13. f. 30.) Length 1-362nd. Boggy pools.

E. *gemmatum* may be known from all in this section, except E. *pectinatum*, by the absence of a linear terminal notch; and from that species by the smallness of the end lobe, and the outward direction of its angles, and by the minute granulation of the projecting parts. Length 1-442nd.

3. *Frond without a distinct terminal lobe, and frequently having a process or an acute angle at the corners of the terminal portion.*

E. *rostratum*, minute, oblong; ends protuberant, emarginate, and angular, with a horizontal spine on each side ; neck, attaching the terminal lobe of each segment, short and broad. The angular and less prominent ends distinguish it from E. *elegans.* Sporangia spinous. Length 1-649th to 1-508th.

E. *elegans*, very minute, oblong; ends emarginate, pouting and rounded.

Var. *(a.)*—Segments slightly constricted beneath the end lobe, which has on each side a short horizontal spine.

Var. *(b) inerme ;* segments sinuated rather than lobed, and without spines.

Var. *(c.)*—Segments as in *(b)*, but with two or more spines, directed obliquely outwards. Length 1-421st to 1-884th.

E. *binale.*—Segments concave, or truncate at the end ; not pro-

jecting beyond the acute angles. Frond very minute. Terminal notch broad.

Var. *(b.)*—Quadilateral form; truncate ends, with a small but distinct notch at the centre. Length 1-1968th to 1-1106th.

EUASTRUM *cuneatum*.—Segments cuneate, not lobed; terminal notch not linear. Frond larger than that of any other species in this section. Ends truncate. Length 1-208th.

E. (?) *sublobatum*.—Segments sub-quadrate, somewhat contracted beneath the end; end margin slightly concave. Sides and end of segments somewhat sinuated, and their base slightly inflated. This species has close affinities with *Cosmarium*. Length 1-523rd.

E. *cornutum* (Kütz.)—Segments three-lobed; terminal lobe cuneate, included between two process-like projections of the basal portion.

E. *pelta*. (Corda.)—Segments quadrangular; end margin with a rounded protuberance at each corner; lateral margins with a small protuberance at the basal end, and a larger one nearer the outer end.

E. *crenatum*. (Kütz.) may be a variety of *E. elegans*.

E. *crenulatum* (Ehr.)—Small, corpuscles binate, elliptic, granular; margin with 8 to 12 crenatures. Size 1-1150th.

E. *binale* (Ehr.) = *Hetorocarpella binalis* (Turpin.)—Corpuscles binate, sub-orbicular, distinctly tri-lobed on each side; each of the terminal lobes truncate; the middle contiguous lobes rounded. Diameter 1-480th. Under the above name, both Ralfs and Ehrenberg have described the *Heterocarpella binalis* of Turpin; yet the descriptions would scarcely identify the same species, and the difference in size, as stated by the two naturalists, is very considerable. Ehrenberg's description is from a paper published in 1840.

E. *octolobum* (Ehr.)—Corpuscles binate; frond oblong, plane, four lobed on each side, the intermediate contiguous lobes bidentate at the apex. Diameter 1-570th.

E. (?) *pygmæum* = *Frustulia coffeæformis*.—Binate, very small, elliptic, smooth, quite entire, imbedded in a gelatinous substance with other specimens (social.) Diameter 1-1750th. Marine.

Genus COSMARIUM.—Corpuscles simple, constricted in the middle; segments as broad as, or broader than long; neither sinuated nor notched; mostly inflato-compressed, but in some species orbicular, or cylindrical. Ehrenberg united plants belonging to this genus with others having lobed segments, in order to form his genus *Euastrum*

Those species having cylindrical fronds, show an affinity with *Penium;* but in that genus the constriction is either wanting or obscure, and the segments are longer than broad. *Cosmarium* is always constricted in the middle, and the starch vesicles are scattered. *Tetmemorus* differs in its elongated fronds and emarginate extremities.

1. *Frond compressed, deeply constricted at the middle; end view elliptical.—Margin of segments entire.*

Cosmarium *quadratum.*—Minute, smooth, deeply constricted; segments in front view quadrate, and on each side of the base slightly protuberant; its ends less rounded than in *C. cucumis.*

C. *Cucumis* = *Euastrum integerrimum,* Ehr. (?)—Smooth, deeply constricted; segments as broad as long, rounded at the ends; transverse view broadly elliptic; smaller than C. *Ralfsii,* less orbicular, and transverse view different.

Cosmarium *Ralfsii.*—Large, orbicular, smooth; deeply constricted; transverse view fusiform. Differs from C. *Cucumis* by its larger size and disciform appearance. Length 1-225th.

C. *pyramidatum.*—Oval, with flattened ends, deeply constricted; segments punctate, entire. Frond about twice as long as broad, varying much in size. Sporangia orbicular, and tuberculated. Distinguished by its puncta and depressed ends.

C. *tinctum.*—Very minute, smooth; constriction producing a linear notch on each side; segments elliptic; integument reddish; sporangium naked, subquadrate, conjugating fronds persistent. Smaller than C. *bioculatum*, and its notches less gaping.

C. *bioculatum.*—Very small; smooth; constriction producing a gaping notch on each side; segments sub-elliptic, entire; sporangium orbicular, spinous. Differs from C. *phaseolus* in its smaller size, and more elliptic segments, which are not in apposition.

C. *deperessum* (Bailey.)—Elliptical, binate, division in the plane of the longest axis. Segments entire, nearly twice as long as broad. Lakes in Florida. This species resembles C. *bioculatum,* (Brébisson.) But the segments are much closer together, and are angular, not rounded at the basal extremities.

C. *granatum.*—Constriction of frond forming a linear notch on each side; segments compressed, smooth, truncato-triangular. Larger than C. *bioculatum* and C. *Meneghinii.* Length 1-1234th.

† † *Margin of segments crenate; surface not granulate.*

COSMARIUM *Meneghinii.*—Exceedingly minute; smooth, deeply constricted; segments sub-quadrate; sides and ends bicrenate. Transverse view elliptic. (1-853rd.)

C. *crenatum.*—Punctate, deeply constricted; segments crenate, and flattened; spines of orbicular sporangia very short. Smaller than C. *margaritiferum;* end view elliptic. The depressed ends distinguish this species from the next. (1-474th.)

C. *undulatum.*—Deeply constricted; segments semi-orbicular, crenate; sporangia with elongated spines. Transverse view elliptic. (P. 13. f. 33. 34.) f. 34 shows the sporangium.

† † † *Frond with pearly granules, which give a denticulate appearance to the margin.*

C. *tetraophthalmum.*—Compressed, deeply constricted; segments semi-orbicular, rough with pearly granules; hence margin crenate. Larger than C. *margaritiferum.* Transverse view broadly elliptic. Sporangia large, with branched spines.

C. *ovale.* = *Euastrum carinatum* (Ehr.)—Large elliptic; deeply notched, linear; segments with a marginal band of pearly granules; disc punctate. Granules confined to the margin, in 3 to 6 rows, leaving the disc free. Length 1-139th.

C. *Botrytis.* = *Euastrum botrytis* and E. *angulosum* (Ehr.)—Granulate; with a deep linear constriction; segments in front view, truncato-triangular; end view elliptic. Margin denticulate. Sporangia orbicular, spines elongated, and slightly divided at the apex. (1-460th.)

C. *margaritiferum.* = *Euastrum margaritiferum* (Ehr.)—Rough, with rounded pearly granules; segments semi-orbicular, or reniform; end view elliptic; notch linear. Sporangia orbicular, enclosed in a granulate cell, usually somewhat angular.

The rough frond distinguishes it from C. *crenatum* and C. *undulatum;* its rounded ends from C. *botrytis,* and its less angular shape from *C. conspersum.* Size variable. (P. 2. f. 126.)

C. *Brébissonii.*—Compressed, rough with conic spines, or granules; segments semi-orbicular; end view elliptic. Larger than C. *margaritiferum;* notch deep, linear; granules or spines longer than broad. (1-285th.)

COSMARIUM *conspersum.*—Rough with depressed granules; segments quadrilateral; end view elliptical, larger than *C. margaritiferum:* notch on each side linear deep. Is peculiar in its quadrilateral figure, and linear disposition of its granules. (1-260th.)

C. *amœnum.*—Twice as long as broad, with parallel sides and rounded ends; rough, with pearly granules; smaller than *C. margaritiferum;* notch linear and deep. In form, it resembles the cylindrical rather than the compressed species. (1-560th.)

2. *Constriction, in the front view, forming a linear notch on each side; end view with a lobe or protuberance on each side.*

† *Frond rough, with pearly granules.*

C. *biretum.*—Segments compressed, quadrilateral, broadest at the end; end margin convex. Frond larger than that of any other species in this section. The empty frond punctate rather than granulate. End view slightly inflated at the middle. From all except C. *Broomeii*, this species is known by its quadrangular segments, the lateral margins of which are sloped and straight, not rounded. (1-330th.)

C. *Broomeii.*—Segments compressed, minutely granulate, quadrilateral; end view slightly inflated at the middle; end margin straight. The inflation does not project at the margin in the front view as in *C. ornatum;* the lateral margins are also less rounded, and the pearly granules smaller (1-500th.)

C. *cælatum.*—Suborbicular; segments crenate, rough with pearly granules; end view slightly inflated at the middle. (P. 13, f. 26—shewing the process of self-division.)

C. *ornatum.*—Segments twice as long as broad, rough with pearly granules, giving a dentate appearance to the margin; inflation forming a truncate projection at the end; end view cruciform. The frond is generally smaller than that of *C. margaritiferum;* notch linear. Sporangia spinous; spines elongated, slightly divided at the extremity, and dilated at the base.

C. *commissurale.*—Segments narrow, reniform, three times broader than long; rough with pearly granules; end view with a constriction between the central inflation and the extremities. Smaller than that of any other species in this section. Sporangia orbicular; spinous.

COSMARIUM *cristatum.*—Orbicular, deeply constricted, margined by papilla-like pearly granules; end view linear, with an inflation at the middle of each side. (1-700th.)

† † *Frond Smooth.*

C. *Phaseolus.*—Segments smooth, reniform; notch linear on each side; end view elliptic, with a slight projection at the middle of each side. Larger than *C. bioculatum;* and its segments are reniform, and the notches linear, not gaping. (1-687th.)

C. *Papilio.*—Segments smooth, triangular, with rectangular apex; end view linear with a lobe at the middle of each side. This species, named by *Meneghini,* is appended by Mr. Ralfs to those known to himself, and appears to fall under this sub-section.

3. *Constriction not forming linear notches at the sides; end view circular.*

† *Frond rough with pearly granules, which give a denticulate appearance to the outline.*

C. *cylindricum.*—Segments granulated, sub-quadrate in front view; broadest at the extremity; minute, cylindrical, about twice as long as broad. (1-588th.)

C. *orbiculatum.*—Minute; segments spherical, granules wanting on the neck-like contraction between the segments. Transverse view has a large central opening.

† † *Frond smooth.*

C. *moniliforme = Tessarthra moniliformis,* (Ehr.)—Segments spherical, smooth.

Var. *(a.)*—Segments united without the intervention of a neck.

Var. *(b.)*—Segments united by a distinct neck. (P. 2, figs. 105, 106.)

C. *connatum.*—Segments punctate, each about two-thirds of a circle, uniting by their plane surfaces; fronds slightly constricted at the middle. Very large (1-285th.)

C. *Cucurbita* (?) = C. *Palangula,* (Bréb.)—Minute, sub-cylindrical; punctate, slightly constricted; rounded at the ends. (1-586th.)

C. *Thwaitesii.*—Cylindrical; constricted; ends rounded; puncta very indistinct, two or three times longer than broad. It differs from *C. Cucurbita* in its larger size and indistinct puncta; from *C.*

curtum, in its differently arranged endochrome; and from *C. turgidum* and *C. attenuatum*, in its nearly parallel sides. (1-357th.)

Cosmarium *curtum*.—Minute, smooth; oblong; constricted; rounded at the ends; endochrome in longitudinal fillets. End view circular. (1-465th.)

C. *attenuatum*.—Fusiform, three or four times longer than broad; slightly constricted; ends obtuse. It is doubtful, says Mr. Ralfs, whether this and *C. turgidum* ought not to be removed to *Penium*.

C. *turgidum*.—Large, turgid, oblong, punctate, constricted ends broadly rounded. It differs from the allied species in its much larger size. It is comparatively longer and more tapering than *C cucurbita* and *C. Thwaitesii*, and its ends are more rounded than those of *C. attenuatum*. Length 1-126th.

C. *lagenarium*, (Corda). — Segments triangular; all the angles broadly rounded.

C. *ventricosum* (Kütz.)—Mr. Ralfs says, "I believe this to be a species of *Cosmarium* in a dividing state."

Genus Xanthidium, (Ehr.)—Simple, constricted in the middle; segments compressed, entire, spinous, having a circular projection near the centre, which is usually tuberculated. Segments reniform, orbicular, or angular; spines scattered or arranged in two rows, one on each side of the marginal line.

The resemblance of *Xanthidium* and *Staurastrum* is more apparent than real, the cells of the latter are angular, irrespective of the processes. In *Arthrodesmus*, each segment has only two spines, one on each side, and there are no central projections. The connection with *Cosmarium* is far more intimate; in fact, the sole distinctive character that can be relied upon, is the presence of spines in this genus.

Several plants referred by Ehrenberg to *Xanthidium*, are angular in the end view, and properly belong to *Staurastrum*, thus: *X. hirsutum* = *Staurastrum hirsutum*, (Ralfs.)

Agassiz believes the *Xanthidia*, generally to be the sporangia of Algæ; but he adduces but one instance in favour of this notion, where he observed *Xanthidia*, growing as *Sporangia*, upon the branches of an Algæ, surrounded with mucus.

Ehrenberg's characters of the genus *Xanthidium* or *double-bur*

Animalcules, are their "being free (devoid of pedicle or stalk) and having a simple univalved lorica, of a globular form, surrounded with spines. They are found either single, in pairs, or groups of four. Ehrenberg thinks they may sometimes be developed in the form of a chain. The lorica is clear, like glass or parchment, covered with simple or branched bristle-like spines. No apertures have been discovered in the lorica, nor has any locomotive organ been seen. The green mass of granules in the interior is considered as ova, and the glandular transparent globule observed in the centre of *X. aculeatum* as a testes. The only character of the animal nature of this genus is its self-division"

All the species (as understood by Ehrenberg, see p. 260), have been found in a fossil state in flints. In some sections, which I cut in 1834, they were very abundant, but until Ehrenberg's observations on them were known, they were not identified with recent species, and then considered as mere defects in the stone.

XANTHIDIUM *difforme*, (Ehr.) = *Ankistrodesmus falcatus*, (Ralfs.)

Mr. Ralfs has arranged this genus as follows:—

* *Spines divided at the apex.*

X. *armatum.*—Segments broadest at the base; spines short, stout, terminated by three or more diverging points. Comparatively large; a deep linear constriction on each side. The central protuberances are cylindrical, truncate, and bordered by pearly granules. Empty frond minutely punctate. End view elliptic. Length 1-180th. Not uncommon at the bottom of shallow pools.

* *Spines subulate.*

X. *aculeatum* (Ehr.)—Spines subulate, more or less scattered, central projections truncate, obscurely dentate, with a border of pearly granules. (Fig. 109.) This species is distinguished from all the following, by having its spines more or less scattered. Length 1-384th to 1-377th. Breadth 1-393rd to 1-347th.

X. *Brébissonii* = X. *bisenarium* (Ehr.)—Spines subulate, marginal, geminate; central projection somewhat truncate, and margined with pearly granules.

Var. (*b*) *varians.*—Segments broader and more irregular; spines somewhat irregular and unequal. The number of spines is variable Length 1-416th. Breadth 1-408th.

XANTHIDIUM *fasciculatum* (Ehr.)—Segments with four to six pairs of subulate marginal spines; central projections minute, conical, not beaded.

Var. (*a.*)—Each segment with four pairs of spines.

Var. (*b.*)—Six pairs of spines to each segment. Length 1-454th. to 1-350th.

X. *cristatum.*—Segments with a solitary spine on each side at the base; the other spines geminate, (P. 13. f. 18 and 23, the latter an end view.)

Var. (*a.*)—Segments reniform; spines scarcely curved.

Var. (*b.*)—Segments truncate at the end; spines uncinate. Length 1-357th.

X. (?) *octocorne* (Ehr.) also = *Arthrodesmus octocornis* (Ehr.)—Segments much compressed, without a central protuberance, trapezoid; each angle terminated by one or two spines. Frond minute; interval between the angles concave.

Var. (*a.*)—One spine at each angle.

Var. (*b.*) *major.*—Larger, two or more spines at each angle.

The proper position (says Mr. Ralfs) of this plant, wanting, as it does, the central protuberance, is very doubtful. Ehrenberg placed it first in *Arthrodesmus,* and afterwards in *Xanthidium.* Length 1-1351st to 1-1020th. Common.

X. *Artiscon* (Ehr.)—Segments narrowed at the base; and margin with numerous elongated spines, which are divided at the apex into three lobes. Figured by Dr. Bailey.

It differs from X. *armatum* by its segments tapering at the base; its spines also are much longer and are more restricted to the outer and rounded margin. Diameter 1-1152nd to 1-288th.

X. *furcatum* (Ehr.)—Corpuscles globose, green, single or binate, spinous; spines scattered, forked at the apex. Size 1-570th to 1-280th (fig. 110.)

This is probably a *Staurastrum.* According to Ehrenberg the corpuscles sometimes occur in fours; also some have but one spine, and some short and broad processes. The spines are usually half the length of the body.

Under the name *Xanthidium,* Ehrenberg described various bodies, more or less branched and orbicular (P. 12. f. 511 to 515) found in

sections of flints, and also fossil occasionally in earth. The reference of these fossil organic remains to this genus is not supported by any accurate examination, and not even by outward characters; their general characters are as those of spores of *Desmidieæ* and of other microscopic Algæ.

The number of these so-called fossil *Xanthidia* has been much added to by other observers; we append those given by Ehrenberg.

Xanthidium (?) *ramosum*.—Lorica globose, spinous; spines trifid or branched at their extremities; they vary in number from 6 to 20, and singly or in pairs (P. 12. f. 511 and 515.) Found in flint. Most probably sporangia. Ehrenberg thinks its true place is the genus *Peridinium*, as traces of a transverse groove have been observed. Diameter 1-1150th to 1-280th.

X. *crassipes*.—Lorica globose; large. There are two varieties; in one the thick blunt spines appear distinct, in the other they appear as a fringe around the lorica. Found in flint. Diameter 1-280th.

X. *penicillatum*.—Fossil in earth from the Jura.

X. *pilosum*.—Fossil in earth from the Jura.

X. (?) *tubiferum*.—Corpuscles globose, single and in pairs, aculeate; spines in the form of tubes, dilated and dentate at the apex. Diameter 1-400th.

X. *bulbosum*. — Corpuscles globose, single or binate, aculeate; aculei attenuate, forked at the apex, bulbous at the base. Diameter 1-400th.

Genus Arthrodesmus.—Frond simple, compressed, constricted at the middle; segments smooth, entire, with a single spine on each side. The sporangia spinous. Mr. Ralfs says :—"Where the plants should be placed, to the reception of which I have restricted this genus, has been left in much uncertainty. Ehrenberg, making no distinction between constricted and binate cells, has associated them with others belonging to *Scenedesmus*, to form his *Arthrodesmus*. Mr Jenner considers them to belong to *Staurastrum;* and he believes he has met with one species, some specimens of which were compressed, whilst others had three angles in an end view; whilst it must be further allowed, that in the front view the resemblance to some species of *Staurastrum* is very close.

Although Mr. Ralfs has employed the name *Arthrodesmus* to

designate the present genus, it does not represent the beings which Ehrenberg so named. The A. *convergens*, (Ehrenberg), is the only one retained in the genus by Mr. Ralfs; the A. *truncatus* (Ehr.) is quoted as doubtful, and all the other members are variously distributed, one with *Xanthidium*, and others in *Scenedesmus*.

Ehrenberg's characters of his genus *Arthrodesmus*, are animalcules, free (no pedicle being present); they have a simple univalved compressed lorica, and multiply by spontaneous self-division, in the form of tables, or compressed and articulated ribbons, each animalcule being contiguous to its neighbour. Neither locomotion nor an opening to the lorica has been seen. The chief animal character is self-division, and their close alliance, through *Micrasterias* and *Euastrum*, to *Navicula*, rather than to any known plant. The internal green colouring matter of their parchment-like lorica consists of minute homogeneous granules resembling ova; each cell-like lorica containing from one to three bright bodies, analogous to fecundating glands, which are often accompanied with crystalline vesicles, like polygastric stomachs.

Arthrodesmus *convergens*, (Ehr.)—Segments elliptic; each having its spines curved towards those of the other. Frond smooth, deeply constricted at the middle; the transversely elliptic segments (corpuscles, Ehr.) have on each side a curved spine which converges with the similar one of the other segment. The frond has a gelatinous covering, sometimes distinctly seen, at other times imperceptible. (P. 2, f. 112, 113.) *A. convergens* differs from *A. Incus*, by its larger size and elliptic segments. Length of frond 1-598th to 1-539th.

A. *Incus*.—Minute, smooth; end margin truncate.

Var. *(a.)*—Segments externally lunate; spines diverging.

Var. *(b.)*—Segments gibbous on each side near the base; spines of one segment parallel to, or converging with those of the other. Sporangia orbicular with subulate spines.

A. *minutus*, (Kütz.)—Frond minute; spines diverging.

A (?) *truncatus*, (Ehr.) — Corpuscles green, slightly compressed, campanulate, geminate, externally truncate, spinous. Diameter with spines 1-480th. It is probably a *Xanthidium* or a *Staurastrum*.

The two following forms have been referred, by Ehrenberg, to *Arthrodesmus*, and though in this genus, as understood by Mr. Ralfs,

they can have no place, the descriptions given are totally insufficient to discover their true generic affinity, and we are consequently compelled, for facility of reference to Ehrenberg's descriptions, to introduce them in the present inappropriate place, or otherwise to insert them in an appendix.

ARTHRODESMUS *Tænia.*—Wands narrow, flexible, nearly eight times longer than broad, and smooth. Has the habit of *A. striatulus*, but is more slender.

A. *striatulus (Fragilaria striatulus,* Lyngbye.*)*—Met with in long, soft, green, but not siliceous chains, resembling *Fragilaria rhabdosoma*. Width of chain 1-576th.

Genus STAURASTRUM.—Frond simple; constricted at the middle; end view angular, or circular with a lobato-radiate margin, or, rarely, compressed with a process at each extremity. Frond mostly minute; the segments generally broader than long, slightly twisted, and in many species elongated laterally into a process, so that the constriction on each side is a roundish or angular sinus; in other respects the front view shows the segments quite entire, The end view varies in form: in most of the species it is triangular or quadrangular, and the angles are either rounded or elongated into rays; in some it is circular, with five or more processes, forming marginal rays; in a few species it is compressed, and the extremities terminate by a process.

"Ehrenberg has distributed the *Staurastra* among different genera, according to the number of angles or processes seen in an end view. Thus he refers those with three angles to *Desmidium*, and those with four to *Staurastrum;* and he formed his genus *Pentasterias* for the reception of an organism with five rays. But this arrangement appears unnatural; not only because it separates nearly allied forms, but also because the number of rays is not constant even in the same species. I have generally found the *Pentasterias margaritacea* (Ehr.) with six rays, although not unfrequently with five, and occasionally with seven rays to a segment. *Staurastrum* contains more species than any other genus in the family: their forms are in great variety, and but little affinity can be traced between many of them. *Sporangia* generally spinous. *Staurastrum* differs from *Desmidium* in never forming a filament; and from *Arthrodesmus* and *Cosmarium*, by its angular shape, or by having the ends elongated into processes.

Some species bear a considerable resemblance to species of *Xanthidium,* to which genus Ehrenberg refers them; but in *Xanthidium* the frond, irrespective of the spines, is not angular in the end view, and there is a projection at the centre of each segment in the front view."

Ehrenberg's characters of his genus *Staurastrum* or *the cross-star Animalcules,* are their being free, and possessing a simple univalved four-sided lorica. They are sometimes, perhaps, developed in a filiform chain. No locomotion has been observed; indeed their only resemblance to an animal, even as stated by Ehrenberg, is their increase by self-division, though he thinks the green matter within them ova.

(A.) *Frond smooth, or rough with minute puncta-like granules; end view with the lobes or angles inflated and mucronated or awned.*

† *Frond smooth.*

Staurastrum *dejectum.*—Segments lunate or elliptic; constricted portion very short; end view with inflated awned lobes.

Var. *(a.)*—Segments externally lunate; awns directed outwards.

Var. *(b.)*—Segments elliptic; awns parallel.

Var. *(c.)*—Awns converging.

The conjugated fronds are connected by the formation of a bag-like receptacle or cell, colourless and very thin; into this sac the endochrome of the two fronds passes, forms an orbicular body which increases in density, becomes hairy and ultimately spinous, and constitutes a perfect sporangium. S. *dejectum* is larger than S. *cuspidatum,* its spines are shorter, and its segments are connected either without a band, or by a very short one. Length of frond 1-833rd.

S. *cuspidatum.*—Segments fusiform, connected by a long narrow band; awns parallel or converging, but straight; end view with 3 to 4 inflated awned lobes. Length 1-883rd. Sporangia with fewer spines than those of S. *dejectum.*

S. *aristiferum.*—Lobes in front view prolonged into mammillate awned projections which are somewhat constricted at the base; end view with 3 to 4 awned lobes. (1-657th.)

S. *Dickiei.*—Differs from the three preceding species in its more turgid sub-elliptic segments, and in the short, curved, converging spines. End view with three slight inflated mucronate lobes. (1-855th.)

S. *brevispina.*—Segments turgid, elliptic, minutely mucronate;

end view three-lobed, each lobe terminated by a short mucro. Larger than S. *dejectum*. Length 1-502nd.

† † *Frond rough, with minute granules.*

Staurastrum *lunatum*.—Granules puncta-like, segments externally lunate, with an awn at each angle; end view with three inflated awned lobes. Its rough frond distinguishes it from all the preceding species, and the inflated awned lobes of its end view from the following ones. Length 1-856th.

(B.)—*Frond smooth; angles in end view broadly rounded.*

S. *muticum*.—Segments elliptic, end view shewing slightly concave sides, and 3 to 5 rounded angles. It possesses a mucous covering, frequently indistinct. It differs from *S. orbiculare* by its elliptic segments and numerous coverings. Length 1-674th.

S. *orbiculare* = *Desmidium orbiculare*, (Ehr.)—Segments semi-orbicular; end view bluntly triangular. Sporangia orbicular, with subulate spines. Length 1-1037th.

S. *tumidum*.—Segments smooth, elliptic, or sub-orbicular; end view bluntly triangular, each angle terminated by a nipple-like projection. Frond large, visible to the naked eye; with a distinct gelatinous covering. In both views the margin appears striated. Empty frond minutely punctate. Length 1-200th.

(C.)—*Frond with simple spines, hairs, or (rarely) acute granules; angles in end view broadly rounded and entire.*

S. *muricatum* = *Desmidium apiculosum*, (Ehr.) — Segments semi-orbicular, rough with conic granules; end view triangular, with convex sides and broadly rounded angles. It is larger than S. *hirsutum*, and not hirsute; in the end view also, its sides are more convex. Length 1-409th.

S. *hirsutum* = *Xanthidium hirsutum*, (Ehr.)—Semi-orbicular, rough, with numerous scattered hair-like spines; end view with three rounded angles, and straight or slightly convex sides. Sporangia orbicular, spines short, and branched at the apex. Length 1-676th to 1-468th. (P. 12, f. 512.)

S. *teliferum*.—Segments reniform, bristly; end view triangular with concave sides, and broadly rounded bristly angles; spines scattered. It differs from S. *hirsutum* in its longer spines, which are also fewer, stouter, and in the end view confined to the angles.

It is larger than S. *Hystrix*, its spines more numerous, and the end margins, in front view, convex. Length 1-597th.

STAURASTRUM *Hystrix*. — Segments sub-quadrate, spinous; end view with 3 to 4 rounded angles, each furnished with a few subulate spines. Frond smaller than that of any other species with simple spines. End view triangular or quadrangular, with concave sides and rounded angles. Length 1-1075th to 1-1020th.

(D.)—*End view of frond showing four or more toothed lobes, which are either truncate or rounded, but never elongated into rays.*

S. *quadrangulare*.—Smooth; segments quadrangular, with a few marginal spines or teeth; end view quadrilateral, with truncate angles either emarginate or dentate. Length 1-1157th.

S. *sexcostatum*. — Large, rough with conic granules which give a dentate appearance; segments in front view with a toothed angle at each side; end view circular, with 5 to 6 broad, short-toothed lobes. The transverse view has a large central opening, surrounded by a row of large granules. Length 1-661st.

(E.)—*Frond smooth; end view acutely triangular; with two accessory subulate spines to each angle.*

S. *monticulosum*.—Rather large segments with a forked spine on each side, and at the end about four short, stout, acute projections; end view acutely triangular, with a bifid appendage to each angle. Very rare.

S. *pungens*.—Each end with about six subulate spines, directed outwards; each angle in the end view tapering into a spine, which has two smaller ones at its base. Its spines are more slender than those of S. *monticulosum*, and in the front view are all simple and directed outwards. Rare.

(F.)—*Frond smooth; front view with diverging processes divided at the apex.*

S. *brachiatum*.—Minute; front view with thick diverging processes, deeply bifid or trifid at the apex; end view with 3 to 4 rays. Frond scarcely constricted at the middle. Sporangia quadrate and spinous. Length 1-1111th.

S. *læve*.—Minute, smooth; segments with short processes, forked at the apex and directed outwards; end view with 3 to 4 bipartite angles; deeply constricted at the middle, thus differing from S.

brachiatum. In end view S. *læve* is unlike any other species. Length 1-1220th.

(G.)—*Frond rough, with puncta-like granules.*

† *End view with entire, rounded or truncate angles or short rays.*

STAURASTRUM *alternans.*—Segments rough; with pearly granules; narrow, oblong, and, from their twisted position, unequal in the front view; end view triangular, with the angles of one segment entire, and alternating with those of the other. (P. 13, f. 16, 17.)

S. *alternans* may be known from S. *dilatatum* and S. *punctulatum* by its unequal segments in the front, and alternating angles in the end view. Sporangia orbicular, with spines forked at the apex. Length 1-1037th.

S. *punctulatum.* — Segments rough, with puncta-like granules, elliptic, equal; end view triangular, with broadly rounded angles and slightly concave sides.

In S. *rugulosum* the pearly granules are larger and fewer, and at the angles appear like little spines. Length 1-704th.

S. *dilatatum,* (Ehr.)—Segments rough, fusiform, equal; end view quadrangular, with four short, broad, truncate and entire rays. Frond very minute; deeply constricted at the middle; the sinuses rounded. (P. 2, f. 100, 101.) It differs from S. *alternans* in not being twisted; its rays also (in an end view) are more truncate. Length 1-1201th.

S. *margaritaceum* = *Pentasterias margaritacea,* (Ehr.) — Rough, tapering at the constriction, and having short lateral processes; end view with five or more short, narrow, obtuse rays. (P. 2, f. 104.) Length 1-1176th.

S. *tricorne* = *Desmidium hexaceros,* (Ehr.)—Rough, with puncta-like granules; tapering at each side into a short, blunt, mostly entire process; end view with three to four blunt angles.

Var. *(b.)*—Processes terminated by minute spines. (P. 2, f. 99.) It frequently bears a close resemblance to S. *alternans* from the twisting of its segments; the tapering of the segments at their sides is its chief distinction. Sporangia orbicular, with spines divided at the apex. Length 1-1275th to 1-948th.

† † *Angles terminated by minute spines, or tapering into slender processes.*

STAURASTRUM *polymorphum*.—Rough, with minute granules, having on each side a short process tipped with spines; end view three to six rayed. Much smaller than S. *gracile*, deeply constricted; segments irregular in form, but generally broader than long. Sporangia orbicular; their spines few and forked. (P. 13, figs. 20, 21, 24, 25, 31.)

The segments are very variable in form, and often resemble those of S. *tricorne*, and S. *margaritaceum*, but in these species the processes are never spinous. S. *polymorphum* is smaller and less spinous than S. *asperum*. Length 1-1000th.

S. *gracile*.—Rough, elongated on each side into a slender process, terminated by minute spines; end view, triradiate. Frond deeply constricted at the middle; granules in transverse lines on the processes. It differs from S. *tricorne* in its elongated processes terminated by minute points. Length 1-773rd to 1-539th.

S. *Arachne*.—Minute, rough, with minute granules, suborbicular, with elongated, slender, incurved processes; end view with five linear rays. Remarkable by its slender processes. Very rare. Length 1-1026th.

S. *tatracerum* = S. *paradoxum* (Ehr.)—Minute, rough; front view with four slender diverging processes, entire at the apex; end view compressed, with a process at each extremity. Length 1-2703rd. (P. 2. f. 102, 103.)

S. *paradoxum*.—Very minute, rough; front view with elongated diverging processes, which are minutely trifid at the apex; end view quadrangular, or sometimes triangular.

Var. (*b*.)—End view triradiate.

Frond generally much constricted; ends truncate; each segment has generally, four elongated processes diverging from those of the other segment. S. *tetracerum* has but two processes to each segment, and these are also undivided, and more slender than those of S. *paradoxum*. Length 1-941th.

(H.) *Frond spinous or rough, with spine-like granules, which are incrassated, emarginate or divided,*

† *Spines minute, inconspicuous, and granule-like.*

S. *cyrtocerum*.—Rough, with minute granules; segments in front view somewhat triangular, with short *incurved* (converging) pro-

cesses; deeply constricted at the middle. End view with three blunt angles. Length 1-800th.

STAURASTRUM *asperum*.—Segments elliptic or somewhat cuneiform, with minute spines, which on the outer margin are usually dilated at the end, or forked. Sporangia orbicular; their spines twice branched.

Var. (*a.*)—Angles in end view rounded.

Var. (*b.*) *proboscideum* (Bréb.)—Angles in end view prolonged into short rays, terminated by minute spines.

† † *End view acutely triangular; segments, in the front view, with a forked spine on each side, otherwise smooth.*

S. *avicula*.—Segments with a forked spine on each side; each angle, in end view, terminated by a mucro-like spine. Frond very minute; scarcely rough; the constriction producing wide triangular notches. The forked lateral spines of the front view mark the species. Length 1-907. Very rare.

† † † *Lobes in end view broad, emarginate or bipartate.*

S. *enorme*.—Irregular or quadrate, spinous; end view three to four lobed; lobes broad, more or less emarginate or bifid, and terminated by spines, which are either simple or branched In the end view the broadly emarginate lobes, which, exclusive of the spines, are truncate, afford a good specific distinction between it and any other species. Length 1-601th.

† † † † *Spines numerous, conspicuous; angles in end view either rounded, acute, or extended into processes.*

S. *spongiosum*. = *Desmidium ramosum* (Ehr.) — Large, thickly covered with short forked spines; segments semi-orbicular, having on each side one spine more conspicuous, and more forked than the rest. End view triangular, fringed with short notched spines; the sides slightly convex, and the angles rounded. Length 1-500th. to 1-418th.

S. *controversum*.—Deeply constricted, spinulose; segments elliptic or fusiform, with a short process on each side, terminated by minute spines; end view with three to four distorted rays. Perhaps a variety of S. *aculeatum*. Length 1-972nd.

S. *aculeatum*. = *Desmidium aculeatum* (Ehr.)—Spinulose; constriction deep, producing a broad triangular notch on each side; segments

with a short process on each side, terminated by minute spines; end view with three to five straight rays, terminated by spines. Length 1-666th.

STAURASTRUM *spinosum.*—Constriction deep; segments elliptic, furnished with a few bifid spines; lateral spines solitary, larger and more forked; end view triangular, with two to three spines on each side, and one terminating each angle. Sporangia orbicular, with numerous elongated spines, forked at the apex. M. Brébisson considers this identical with *Xanthidium furcatum*, (Ehr.) Length 1-859th.

S. *vestitum.*—Rough, with minute emarginate spines; segments fusiform; end view tri-radiate, each side having two spines, short, slender, and often accompanied by other smaller ones.

Its most distinctive character is the presence of the pair of slender forked spines at the middle of each margin. Length 1-625th.

S. *pygmæum* (Bréb.)—Segments cuneiform; end view triangular, with slightly rounded sides. It is smaller than S. *alternans*, its sides, in the end view, are more convex, and its angles less rounded. The sporangium is orbicular and spinous.

S. *rugulosum* (Bréb.)—Segments elliptic, denticulate at their sides; end view triangular, with the angles broadly rounded and denticulate.

S. *scabrum* (Bréb.)—Segments elliptic, scabrous; end view triangular, fringed with minute emarginate spines.

S. *bacillare* (Bréb.)—Smooth; processes capitate; end view with three to five capitate rays or processes. Processes in front view stout; divergent.

S. *capitulum* (Bréb.)—Segments quadrate, sinuated on each side, prominences rough; end view triangular, with broadly rounded angles. Central constriction of frond shallow; the prominences of segments are rough, with minute granules, which give them a crenate appearance. End margin straight.

S. *pileolatum* (Bréb.)—Quadrilateral, twice as long as broad, slightly constricted at the middle; segments quadrate, terminated by three conical processes, rough, with minute granules. End view triangular, angles rounded.

STAURASTRUM *echinatum* (Bréb.)—"Appears, from M. de Brébisson's drawings, to be closely allied to S. *hirsutum*, and S. *teliferum*."

S. *crenatum* (Bailey)—Segments cuneate; outer margins crenate; end view with three truncate and crenate angles.

S. *bifidum*. = *Desmidium bifidum* (Ehr.)—Smooth; end view with three cloven angles.

S. *eustephanum*. = *Desmidium eustephanum* (Ehr.)—End view triangular, with six emarginate spines on the upper surface; each angle terminated by a short ray, tipped with spines. (P. 13. f. 3.)

S. *senarium*. = *Desmidium senarium* (Ehr.)—Ehrenberg's figure represents the end view as triangular, the angles terminating in short rays, tipped by minute spines; on each side are two short forked spines, and six others on the upper surface. His figure agrees in some respects with S. *spinosum*. (P. 13. f. 7.)

S. *Ehrenbergii* (Corda.)—Segments oval; end view triangular, with six terminal and lateral processes, and two central ones, which are short, colourless, and forked, with diverging apices. Corda's figure of the front view resembles S. *spinosum*.

S. *articulatum* (Corda.)—Segments oval, their ends furnished with a forked process, and laterally with two larger furcate appendices. The flat surface has two transverse protuberances, with forked spines.

S. *coronatum* = *Xanthidium coronatum* (Ehr.)—End view triangular, and terminating at each angle in three short, diverging arms, which are divided at the apex.

S. (?) *minus* (Kützing.)—Smooth; end view with five slender acute rays.

S. *glabrum* = *Desmidium glabrum* (Ehr.)—Smooth; end view triangular, each angle terminated by a mucro-like spine. This species is probably identical with S. *auricula*.

S. *granulosum* = *Desmidium granulosum* (Ehr.)—Known only by name to Mr. Ralfs.

S. *globulatum*.—Segments fusiform, capitate; end view globular, each angle terminated by a granulated knob.

Genus PENTASTERIAS (Ehr.)—*The five-rayed Desmidieæ.*—Lorica simple, univalve, five-sided, with a central aperture; free, but sometimes developed in chains.

This genus, instituted by Ehrenberg, contained, in 1838, but one species, called P. *margaritacea*, the *Staurastrum margaritaceum* (Ralfs),

but subsequently (1840) two other species were added, which, from the given characters, we presume to be *Staurastra*, but shall describe them in Ehrenberg's own words.

Pentasterias *obtusa.*—Corpuscles solitary, sub-orbicular, pentagonal, green ; laterally, ovate oblong, smooth. Diameter 1-1150th.

P. *radiata.* — Corpuscles in pairs, with elongated rough rays equalling their diameter, rays connivent; ovarium green, in five segments (quinquefid). Entire diameter 1-860th.

Genus Didymocladon (Ralfs.)—Frond simple, constricted at the middle, angular, each angle having two processes, one lateral, and, in front view, nearly parallel to the adjacent one of the other segment, the other superior and divergent.

This genus is closely allied to *Staurastrum*, but differs by each angle of the segments giving rise to two processes, one beneath the other; whereas, in *Staurastrum*, the process, when present, is solitary.

D. *furcigerus.*

Frond comparatively large, rough, with pearly granules, which, being arranged on the processes in tranverse lines, produce a crenate appearance on their margins. In the front view, the processes are elongated, stout, tapering, bifid at the apex. Length, exclusive of processes, 1-547th. Breadth 1-555th.

Var. (*a.*)—End view triangular.

Var. (*b.*)—End view quadrangular.

Front view.

End view.

D. *cerberus* (Bailey).—Small, deeply constricted, segments three-lobed; lobes with four teeth, two of which project. Lakes in Florida.

D. *longispinum* (Bailey.)—Large, smooth, triangular, with two long spines at each angle. Lakes in Florida.

The two last species are not very nearly allied to each other, nor

to the typical D. *furcigerus*, yet they agree better with the verbal characters of the genus than with those of any other known to Dr. Bailey; therefore, he refers them here provisionally.

Genus TETMEMORUS (Ralfs.)—Frond simple, elongated, straight, cylindrical, or fusiform, slightly constricted at the middle ; segments emarginate at the end, but otherwise quite entire. The frond is elongated, as in *Penium*, but differs in its emarginate ends; the same character and the elongated frond separates it from *Cosmarium*. From *Euastrum*, with which it agrees in the emarginate extremities, it differs in being cylindrical or nearly so, and in the segments being neither lobed nor sinuated; the fronds are also free from inflated protuberances.

T. *Brébissonii*.—In front view with parallel sides, but in lateral one fusiform; ends without any projecting processes; puncta in longitudinal lines (P. 13. f, 12, 13.)

Var. (*b*.) *turgidus*.—Larger; constriction greater; segments somewhat inflated. Frond four to six times longer than broad. The endochrome is dark green ; its large vesicles in a single central row.

T. *lævis*.—Somewhat tapering in front view; ends truncate; lateral view fusiform; puncta none or very indistinct; four to six times longer than broad, constricted at the middle. Length 1-374th.

The process of forming the sporangium is interesting, as it exhibits a striking similarity to the change during the formation of similar bodies in *Staurocarpus* among the *Conjugatæ*. In *Staurocarpus*, after conjugation, a subquadrate cell is formed, within which the endochrome is collected. The latter is at first of the same figure as the cell, but in at least one species, is at length condensed into a compact globular body, and in every species the cell with the contained sporangium, finally separates from the filaments with which it is connected. In this separate state I can discover no character by which to distinguish the sporangium of *Tetmemorus* from one belonging to a species of *Staurocarpus*. Length.

T. *granulatus*.—Fusiform both in the front and lateral views, and ending in a colourless projecting lip-like process; about six times longer than broad; very slightly constricted. Empty frond with scattered puncta; near the central constriction they form one or two tranverse lines in each segment.

It may be distinguished from the preceding species by the front and lateral views being similar. Length 1-133rd.

Genus Penium (Bréb.)—Frond simple, elongated, straight; not, or but slightly, constricted; segments entire; the opposite margins similar; and suture either indistinct or wanting.

It differs from *Closterium* by its straight fronds, with similar opposite margins; from *Tetmemorus* by the absence of a terminal notch, and from *Cosmarium* by its more elongated frond, and its less marked constriction at the junction of the segments; yet the cylindrical species of *Cosmarium* closely approach to this genus, and C. *turgidum* and C. *attenuatum* are, at least, as much elongated as *Penium truncatum*.

Some species of *Penium* are smooth, and, like *Closterium*, have the endochrome arranged in longitudinal fillets, and at each extremity of it a globule containing moving granules. Other species have a granular surface, and there are two smooth and truncate, which some botanists have referred to the *Palmelleæ*.

As in other instances, we follow Mr. Ralfs division of this genus.

* *Empty frond either striated or granulate, generally reddish.*

P. *margaritaceum* = *Closterium margaritaceum* (Ehr.)—Cylindrical, with rotundato truncate ends; pearly granules in longitudinal series.

Var. (*a.*)—Fusiform, constricted at the middle; granules distinct, giving a denticulate appearance to the margin.

Var. (*b.*)—Linear, scarcely constricted at the middle; denticulate on the margin, somewhat scattered near the suture.

Var. (*c.*) *punctatum.*—Linear, neither constricted at the suture, nor denticulate at the margin; granules appearing like puncta. This last form agrees best with Ehrenberg's figure of *Closterium margaritaceum,* but it is not denticulate at the margin.

Length of frond, in *(a)* 1-156th; in *(c)* 1-169th (P. 13, f. 14.)

The sporangia are orbicular. (P. 13, f. 15.)

P. *cylindrus* = *Closterium (?) cylindrus* (Ehr.)—Cylindrical; ends rounded truncate, rough, with pearly scattered granules. Length 1-192nd.

* * *Frond smooth, colourless.*

† *Sporangium situated between the deciduous cells.*

Penium *digitus* = *Closterium digitus*, and *Polysolenia Closterium*. (Ehr.)—Smooth, elliptic-oblong, with rounded ends; fillets obscure, undulated, interrupted only by a transverse band at the suture. Terminal globules wanting, or very indistinct. Length 1-81st. Three to five times longer than broad.

P. *interruptum*.—Smooth, cylindrical; extremities conical, with rounded apices; fillets three to four strongly marked, interrupted by three transverse bands. Ends colourless; each occupied by a large globule containing moving granules, as in *Closterium*. Length 1-116th. Four to six times longer than broad.

P. *closteroides*.—Smooth, fusiform or lanceolate; longitudinal fillets and terminal globules distinct. Ends obtuse; vesicles in a single longitudinal row. Length 1-92nd. Six to ten times longer than broad.

P. *truncatum*.—Very minute, smooth, cylindrical, with truncate ends; sporangia orbicular, easily detached from the conjugated fronds. Two to three times longer than broad. Has a transverse pale band, but, when empty, exhibits no suture. Length 1-969th to 1-555th.

P. *Jenneri*.—Smooth, cylindrical with rounded ends; sporangium orbicular, situated between the conjugating fronds, which are deciduous. It agrees in size and form with P. *Brébissonii*, but differs in the form of its sporangia. The conjugating fronds do not open and gape at the suture, as is usual in the *Desmidieæ*, but couple by small and distinct cylindrical tubes, like many of the *Conjugatæ*. Length 1-810th. Two to four times longer than broad.

† † *Sporangium permanently attached to the conjugated cells, at first quadrate, then orbicular (Cylindrocystis.)*

P. *Brébissonii*.—Smooth, cylindrical, with rounded ends; sporangium at first quadrate, but finally orbicular; conjugating fronds persistent. Minute, often congregated into a mucus stratum on wet mud. The transverse pale central band, which, in the *Desmidieæ*, indicates the line of junction of the segments, is less conspicuous here than in any other species of the family. Length 1-637th to 1-404th.

Genus Docidium (Brébisson.)—Frond simple, straight, much elon-

gated, linear; constricted at the middle; truncate at the ends; segments usually inflated at the base. A suture is generally very distinct, in a line with the constriction. This genus, like *Closterium*, has terminal globules containing moving granules, and its vesicles are either scattered or arranged in a single longitudinal row. It differs from *Closterium* in its straight fronds and constricted middle; and from *Penium*, it may be known by having a distinct constriction at the middle, and more elongated fronds.

DOCIDIUM *nodulosum*.—Large, stout, segments four to six times longer than broad, constricted at regular intervals, so as to produce undulated margins; suture projecting on each side. D. *nodulosum* differs from D. *constrictum* and D. *nodosum*, in its more numerous but slighter constrictions.

D. *truncatum*.—Large, stout; suture projecting on each side. Its distinctive marks are, the more attenuated extremities and the solitary inflation at the base of each segment, so that its margins are not undulated. Length 1-81st to 1-72nd.

D. *clavatum*.—Segments many times longer than broad, with a single inflation at the base; ends clavate, but truncate; suture not projecting. Vesicles small, few, and arranged in a single longitudinal line. Empty frond minutely punctate. Length 1-65th (P. 13. f. 9.)

D. *Ehrenbergii* = *Closterium Trabecula* (Ehr.) — Segments elongated, with two or three slight inflations at the base; ends truncate, bordered by minute tubercles (P. 13. f. 8 and 11.)

Var. *(b.)*—Frond rough, with minute granules. Frond as long as those of D. *nodulosum* and D. *truncatum*, but far more slender; constricted at the middle; suture strongly marked but not projecting.

D. *baculum*.—Segments very slender, having a solitary and conspicuous inflation at the base, otherwise linear; vesicles in a single series. Suture strongly marked, not projecting. Length 1-111th.

D. *minutum*.—Small; slender, slightly constricted at the middle; segments linear, not inflated; vesicles in a single series. Length 1-212th.

D. ? *asperum*.—Slender, twelve or more times longer than broad, cylindrical, rough; Mr. Ralfs has seen neither vesicles nor terminal globules. Unlike all the true *Docidia*, this has neither constriction

nor suture: but it is not unlike the separated joints of a species of *Mougeotia,* but the dilated truncate ends and roughness produced by minute granules distinguish it. Length 1-97th to 1-64th.

DOCIDIUM *coronatum.*—Stout: segments inflated at the base, and bordered by tubercles at the end.

This species differs from D. *nodulosum,* which it otherwise resembles, by having the ends bordered with minute but distinct tubercles.

D. *nodosum.*—Stout; segments with four prominent nodes, separated by constrictions; end view crenate. It is one of the largest species in the genus.

D. *constrictum.*—Stout; segments with moderately deep constrictions, which separate four equal, gently curving prominences; end view entire.

This species, says Dr. Bailey, is at once distinguished from D. *nodosum,* by the cross section of the nodes being a simple circle instead of an indented one; an end view of the latter proving each node to be not a simple swelling, but really a whorl of tubercles.

D. *verrucosum.*—Segments with numerous whorls of small prominences, which give the margins an undulated appearance; all the undulations equal.

D. *verticillatum.*—Segments with numerous whorls of tooth-like projections; ends with three bidentate processes.

These processes are so unlike what we find in other species of *Docidium,* that Dr. Bailey is disposed to form a new genus for the reception of this species.

D. *crenulatum* = *Closterium crenulatum* (Ehr.); and is, according to Bailey, identical with *Docidium nodulosum.*

D. *hirsutum* (Bailey.)—Segments many times longer than broad, slightly inflated at base, surface hirsute. A small species resembling D. *Ehrenbergii* in form, strongly hirsute on its outer surface. Lakes in Florida, at Enterprise.

D. *undulatum* (Bailey.)—Segments eight to ten times longer than broad, constricted six to eight times at regular intervals throughout their entire length, with the base and ends crenate. Smaller than D. *nodulosum,* with more frequent and deeper constrictions. The same characters distinguish it from D. *nodosum* and D. *constrictum.*

Genus Closterium.—Frond simple, elongated, lunately curved or arcuate, entire; the junction of the segments marked by a pale transverse band, but no constriction.

In the usual position, the opposite margins of the fusiform fronds are always more or less dissimilar, the upper one being convex, and the lower, inclusive of the ends, straight, or more commonly concave; the lateral view is straight, and has both margins similar. As happens, in the allied genera, the frond is composed of two segments which finally separate, and allow the escape of the endochrome. The segments are entire, without spines, processes, or inflated protuberances. The endochrome is green, with darker longitudinal bands or fillets, the number of which varies in different species. The diaphanous vesicles, conspicuous in most of the species, are either scattered, or arranged, with more or less regularity, in a single longitudinal series.

At each extremity of the endochrome, even in its earliest state, there is a large hyaline, or straw-coloured globule, which contains minute granules in constant motion. This globule disappears in the dried specimen.

A distinct circulation (rotation) has been noticed in several species. It is said to occur only in species obtained from water, and not in those taken from moist ground. The empty frond is striated in some species, and smooth in others. The colour and firmness of the covering differs in different species. Some are quite colourless, flexible, collapsing when dried, and in general allowing the endochrome to escape by a merely partial separation of the segments. These species are never striated. In other species the fronds are more or less straw-coloured, or even reddish. The deeper the colour, the firmer the frond, The segments in such, separate entirely from each other. Some of the striated species, even when submitted to the action of nitric acid or fire, retain their form and markings. In the coloured species the extremities are generally darker than the rest of the frond."

Even in the firmest species the frond becomes flattened in drying, its breadth at the centre increases, and the ends appear more attenuated than in the living state; a fact to be borne in mind in describing or drawing a dried specimen.

In *Closterium* the process of conjugation appears to be nearly the

same as in the *Conjugatæ*. Two fronds unite by means of projections arising at the junction of the two segments, and then the newly formed portion continues to enlarge until the original segments are separated by a cell of an irregular four-sided figure. The contents of the fronds, being collected in this cell, become a dense seed-like mass, which is sometimes globular, resembling the Sporangium of *Mougeotia*, and sometimes square, like that of *Staurospermum*. The newly-formed cell is thinner, and generally paler than the segments of the frond; in some species it looks like a prolongation of the segments, and in others these are so loosely attached, that their connection is scarcely perceptible. (P. 13. f. 5, 6.)

The coupling of the fronds generally takes place from the convex margin, but may occur on the concave, or even the convex margin of one frond may couple with the concave of the other.

The Rev. W. Smith has presented to naturalists an excellent account, with a series of illustrative engravings, of the phenomena of conjugation in *Closterium Ehrenbergin*, which he states differs from those in other *Closteria* generally, and indeed from those of any other of the *Desmidieæ*. (Annal Nat. Hist. vol. 5, 1850.)

"The first phenomenon is an alteration in the granular condition of the endochrome. This, from a light yellowish green, passes to a much darker shade, and the larger granules, or "diaphanous vesicles" of Ralfs, which were originally few in number, and arranged in a somewhat irregular longitudinal series (P. 18, f. 10), become exceedingly numerous and pervade the entire frond. While this change is about taking place, the fronds approach in pairs, approximating by their concave surfaces, and finally coming into such close neighbourhood that their inflated centres are in contact, and their extremities slightly overlapped. (P. 18, f. 11.) In a short time, probably in the course of twenty-four hours, a remarkable change takes place, both in the appearance and condition of the fronds; a mass of delicate mucus is secreted around the approximated fronds; these remove to a little distance from each other, undergo 'self-division,' and present altogether an irregular oval figure, the outline of which is formed by the periphery of the mucus, the four divisions of the fronds being placed in the middle in a somewhat quadrilateral manner. (P. 18, f. 12.) During the progress of cell-division, the

internal membrane of the cell-wall becomes enlarged at the suture or line of separation, and projects in the form of an irregular cone, with a blunt or rounded apex forming a beak, whose side view presents a triangular outline. This beak becomes filled with endochrome, either by the dilatation or increase of the contents of the half-frond, and the divided frond assumes the appearance of one with two unequal segments (f. 12.) being what M. Morren calls "a *Closterium* of two unequal cones." On these membranous expansions, at the concave surfaces of the fronds, and close to the original sutures, there appear, almost simultaneously with the formation of the beaks, two circular projections, which, rupturing at their apices, give egress to the delicate sacs which enclose the endochrome, and which, drawing with them their contents, and meeting with the endochrome sacs emitted through similar projections from the other half fronds, form, by their connection, irregular masses, which quickly consolidate and assume the appearance of perfectly, circular, smooth, dark-coloured balls, the sporangia of Ralfs and seminules of Morren. (P. 18, f. 13 and 14.)

"The discharge of the endochrome and formation of the sporangia are accomplished with much rapidity, and may often be seen taking place in the field of the microscope, the whole operation not occupying more than a few minutes. It will be seen from an inspection of the figures, that during the formation of the sporangia there appears to be a second development of mucus in the form of rings around the reproductive bodies; this is probably only the effect of the pressure produced by the growth of the sporangia on the mass of investing mucus. It will also be seen that the pale transverse band adopted by Ralfs as a characteristic of the genus *Closterium*, and which in figs. 10 and 11 occupies the centre of the undivided frond, is, upon self-division taking place, removed a little towards the extremities of the half fronds. The reason, as well as the cause of this motion, I am unable to explain, but it seems to confirm the propriety of adopting the band itself as a permanent and important character.

"With regard to the subsequent changes which take place in the sporangia, the time which elapses before they produce young fronds, and the mode in which such evolution of a fresh race is accomplished, I have not been fortunate enough to ascertain with any certainty. ...

"M. Morren contends that a sporangium becomes converted into a single frond, and gives a series of figures in illustration of the changes which the sporangium undergoes until it becomes "a *Closterium* of two unequal cones." (P. 18, figs. 16, 17, 18, 19.) Now as this form is the result of the self-division of the ordinary frond, and invariably precedes conjugation, I am disposed to think M. Morren has mistaken fronds thus divided, and afterwards thrown out of their relative positions, for modified sporangia.

Self-division, in the case before us, seems only to accompany conjugation, and will not, as in the other *Desmidieæ*, account for the existence at certain periods of vast multitudes of the fronds........

"I may remark, that in a generic arrangement, based upon the reproductive organs, *Closterium Ehrenbergii* will stand apart from all the other *Desmidieæ*. In it alone a pair of conjugating fronds produce two sporangia. It is, however, allied to others of the present genus through C. *lineatum*, the sporangium of which, according to Mr. Ralfs, is binate, and shows a disposition to separate into two parts."

"Another mode of increase, analagous to the propagation of Zoospores in Algæ, has been assigned to the *Desmidieæ*, and it has been alleged that the endochrome escapes in the form of zoospores, and becomes transferred into new fronds. M. Morren not only affirms this to be the case, but gives a figure illustrative of the conversion of these zoospores, or as he terms them 'propagules,' into new fronds." (P. 18, f. 15)

Mr. Ralfs states, that "As there is no constriction in *Closterium*, the process of division is less evident. It is best seen in the striated species, in which the central suture is most distinct. The transverse line becomes double, and, by the intermediate growth, the frond at length, consists of three portions, as the newly-formed central one continues to elongate, another transverse line becomes visible at its middle where a complete separation at length takes place. At first, however, the new segment is often merely a rounded protuberance, and the frond is consequently unequal; and when it is perfected, if the covering is a coloured one, the newer segment can still be distinguished by its greater paleness.

"The striated species, besides the central suture, frequently have

other transverse lines that divide the segments themselves into two or more portions. (P. 13, f. 6.)

"*Closterium* may be distinguished from all the other genera of the *Desmidieæ* by its elongated, curved, entire, and attenuated fronds."

The discussion as to the vegetable or animal nature of the *Closteria*, and Ehrenberg's views, are given at page 179, and in the introduction to this section of the family *Bacillaria*.

1.—*Sporangium orbicular, situated between the conjugating fronds and but slightly connected with them; fronds never rostrate (Closterium).*

† *Frond semilunate, or semilanceolate, tapering from the middle, the lower margin straight, (or nearly so), and inclined upwards at the end.*

C. *lunula* (M.)—Large, stout, smooth, semilunate; lower margin nearly straight, inclined upwards at the rounded ends; vesicles numerous, small and scattered. Fillets several; three more distinct than the rest. Empty frond colourless, without markings, and its suture indistinct. Length 1-62nd.

C. *acerosum.*—Linear-lanceolate, gradually tapering, ends conical; fillets distinct; vesicles in a single series; empty frond colourless; striæ none or indistinct (P. 1, f. 63, 64, 65.)

Var. *(b.)*—More elongated; striæ more distinct. Length 1-170th to 1-48th.

C. *lanceolatum.*—Semilanceolate, gradually tapering; ends subacute; fillets several; vesicles in a single series; empty frond colourless. Length 1-64th.

C. *turgidum.*—Lower margin slightly concave, inclined upwards at the rounded ends; upper margin with a depression near each extremity; empty frond coloured; striæ numerous, fine but distinct. Vesicles in a single row; fillets three or more; suture distinct. The curved and rounded ends are characteristic. Length 1-39th (P. 1. f. 66.)

† † *Frond smooth, crescent-shaped, rapidly tapering from the middle.*

C. *Ehrenbergii* = C. *lunula* (Ehr.)—Smooth, stout, crescent-shaped; when empty, colourless; lower margin very concave; inflated at the middle; ends rounded; vesicles numerous, scattered. Length 1-68th. (P. 8. f. 10.)

C. *moniliferum.*—Smooth, crescent-shaped, when empty, colourless;

lower margin inflated at the middle, very concave; ends rounded; vesicles large, in a single row; fillets several; suture absent. It may always be distinguished by the inflation at the middle of its lower margin; its single row of vesicles separates it from C. *Ehrenbergii.* Length 1-75th to 1-60th.

Closterium *Jenneri.*—Small, crescent-shaped, generally slightly constricted at the suture; when empty, colourless; rapidly tapering; ends very obtuse; vesicles in a single series. Length 1-281th.

C. *Leibleinii.*—Smooth, crescent-shaped; extremities much attenuated and sub-acute at the apex; lower margin slightly inflated at the middle; vesicles in a single row, large.

Var. (*b.*)—More slender, the central inflation less evident; empty frond of a deeper colour, and its central suture distinct. Length 1-291th. to 1-165th. (P. 13. f. 1. and 5.)

C. *Dianæ* (Ehr.)—Smooth, slender, crescent-shaped; extremities tapering; apex sub-acute; lower margin not inflated; vesicles in a single series. The empty frond of a pale straw colour, with a central transverse suture. It is less curved than preceding. Length 1-143rd.

† † † *Frond nearly straight, scarcely attenuated; ends truncate; longitudinal striæ none or indistinct.*

C. *didymoticum.* — Nearly straight, broadly linear; extremity slightly tapering; ends truncate; reddish; fillets obscure.

Var. (*a.*)—Empty frond divided by three transverse lines or sutures. Rare.

Var. (*b.*) *Baillyanum.*—Smaller, with a suture only at the middle.

C. *didymoticum* may be known from all the preceding species, by its straight unstriated frond, combined with truncate ends. Length of *var.* (*b.*) 1-65th.

† † † † *Empty frond distinctly striated, mostly coloured.*

C. *attenuatum* (Ehr.)—Curved, attenuated; suddenly contracted at the end into a conical point; empty frond reddish, faintly striated. Rather larger than C. *striolatum.* The sudden contraction of its extremities is characteristic. Length 1-57th.

C. *costatum.*—Stout, semilunate, tapering from the middle; ends obtuse; striæ few and conspicuous; suture solitary. Fillets obscure; vesicles in a single row. Empty frond reddish. Length 1-75th.

CLOSTERIUM *striolatum* (Ehr.) — Closely but distinctly striated, crescent-shaped, tapering from the middle; sutures generally three, never more; ends very obtuse; lower margin never inclined upwards at the ends. Length 1-80th to 1-68th (P. 13, f. 2 and 6.)

C. *intermedium.*—Slender, slightly curved, tapering; striæ distinct, not crowded; sutures usually more than three; ends truncate. Its most remarkable feature is the number of its sutures, which exceeds that of any other species. Length 1-77th to 1-54th.

C. *angustatum.* — Sublinear, curved, scarcely attenuated; ends truncate; striæ few, very distinct and prominent; sutures usually three. Vesicles in a single row; fillets obscure. Length 1-60th.

C. *juncidum.*—Very slender, linear, straight, except the extremities, which are slightly attenuated and curved downwards.

Var *(b.)*—Stouter, and less elongated; its colour, when empty, deeper, and its striæ more conspicuous. Length of *(a)* 1-111th to 1-69th. Length of *(b)* 1-144th.

2. *Frond striated, much elongated, gradually tapering, scarcely rostrate; sporangium bilobed, situated between the conjugated fronds.*

C. *lineatum* (Ehr.)—Striated, slender, long, curved, gradually tapering into the conico-rostrate extremities; lower margin slightly inflated at its centre; fillets three or more, frequently obscure; vesicles in a single row; one or more transverse lines at the centre; longitudinal striæ numerous.

Var. (*b.*)—Longitudinal striæ numerous.

C. *lineatum* connects the rostrate with the other striated species, as in general aspect it agrees with some of the latter, and in its inflated centre and tapering extremities with the former.

The fronds approach and couple in the usual manner; but instead of the contents of both fronds uniting in the ordinary manner into a single body, a bilobed body is produced, not unlike a species of *Cosmarium.* Though called bilobed, Mr. Ralfs regards the sporangium as *binate,* being readily separable at the constricted line of junction. (page 279.) Length 1-48th.

3. *Frond either rostrate or minute, colourless and acicular; sporangium cruciform. (Stauroceras, Kützing.)*

† *Frond striated, tapering at each end into a distinct beak.*

C. *Ralfsii.*—Stout, striated, curved, rapidly attenuated into linear

beaks, which are shorter than the ventricose body. Vesicles disposed rather irregularly in a single row; fillets generally obscure; empty frond reddish. Length 1-79th.

CLOSTERIUM *rostratum* (Ehr.)—Closely striated, tapering at each end into a setaceous curved beak, which is about equal in length to the ventricose body. Fillets obscure; vesicles in a single row. Empty frond colourless or straw coloured. Length 1-69th.

C. *setaceum* (Ehr.)—Very slender, finely striated, narrow lanceolate, tapering at each extremity into a very long setaceous beak, which alone is curved; vesicles none or obscure. Fillets none. Sporangium quadrate or cruciform (P. 1. f. 67.) Length 1-116th.

Ehrenberg discovered this species in May, 1832; and, in 1835, observed the process of copulation (conjugation.) On the issuing forth of the green matter separation took place into four instead of two portions, and the green matter formed itself into a flat eight-cornered body, with a bright spot in its centre, and granular contents. (See figure on right side of group 67, Plate 1.)

† † Frond minute, tapering, not rostrate; empty frond colourless and without markings.

C. *cornu* (Ehr.)—Smooth, minute, curved, very slender; extremities slightly attenuated; ends obtuse; vesicles none or indistinct; sporangium quadrate.

Var. *(b.)*—Frond more turgid. Length 1-140th. Length of var. *(b)* 1-226th.

C. *acutum.*—Curved, gradually tapering at each extremity; ends more or less acute; empty frond colourless, without markings.

Var. *(a.)*—Six to twelve times longer than broad; vesicles obscure; fillets none; ends sub-acute.

Var. *(b.)*—Ten to twenty times longer than broad, tapering at each extremity into a very fine point. Length 1-177th.

C. *cuspidatum* (Bailey.)—Smooth, crescent-shaped; ends mucronate. It differs from every other species of the genus in having each end tipped by a spine or *mucro*.

C. *cucumis* (Ehr.) — Smooth, stout, semilunate; ends broadly rounded. In form it resembles C. *lunula*, but is stouter in proportion to its length, and has its ends more rounded.

C. *Thureti.* — Smooth, crescent-shaped; ends sub-acute; margins unconnected at the suture; vesicles in a single series

CLOSTERIUM *arcuatum*. — Smooth, slender, crescent-shaped, ends obtuse, scarcely notched.

C. *Venus* (Kützing.)—Mr. Ralfs is unable to discover any characters sufficient to distinguish it from C. *Diame.*

C. *amblyonema* (Ehr.)—Stout, linear, slightly curved, twenty times longer than broad; ends rounded.

C. *uncinatum.*—Slender, finely and closely striated; extremities tapering to a sub-acute point, and suddenly curved downwards.

C. *decussatum.*—Stout, finely and closely striated, slightly curved, gradually tapering; extremities slender, but obtuse at the apex. It seems to differ from C. *turgidum* in its more tapering extremities.

C. *turgidulum.*—Stout, curved; extremities slender, gradually tapering; striæ few, conspicuous. It differs from C. *costatum* in its more elongated extremities.

C. *obtusangulum.*—Crescent-shaped; four-sided; angles rounded; ends rounded. Empty frond transparent, colourless, with a narrow central suture,

C. *inæquale* (Ehr.)—Minute, semi-lunate; extremities unequal, conical, ends acute; striæ prominent; vesicles scattered.

C. *quadrangulare.*—Long, thin, quadrangular, the angles acute; endochrome deep green; sutures several, oblique; ends rounded.

C. *gracile.*—Slender, smooth, lanceolate, gradually tapering into short beaks, which are curved downwards. It differs from other rostrate species in its smooth frond. Its beaks are shorter than those of C. *rostratum*, and C. *setaceum*, and it is less inflated.

C. *tenerrimum* (Kütz.)—Mr. Ralfs states he can perceive, in Prof. Kützing's drawing, no character by which it can be separated from C. *acutum.*

Genus SPIROTÆNIA (Brébisson.)—Frond simple, elongated, cylindrical, or fusiform, straight, entire, not constricted at the middle; ends rounded; endochrome spiral, as in *Zygnema;* this circumstance distinguishes it from every other genus. It differs from *Tetmemorus* in the entire extremities, and absence of central constriction; and, in the latter, likewise from *Closterium.* The extremities are also without globules. It closely resembles *Zygnema* in its endochrome, but does not form a filament, the cells dividing in the manner of the *Desmidieæ*, but obliquely as in *Scenedesmus.* In *Spirotænia* complete division of the cell is prior to the division of the

gelatinous covering, which thus retains the two newly-parted cells together for some time longer, a fact which convincingly proves that this genus belongs to the *Desmidieæ.*

SPIROTÆNIA *condensata.*—Endochrome, a single, broad, closely spiral band. Frond bright yellow-green, cylindrical. Length 1-208th. (P. 13. f. 4.)

S. *obscura.*—Endochrome at first in several slender spiral threads, afterwards uniform. Frond dark green; extremities attenuated. Length 1-247th. to 1-226th.

Genus ANKISTRODESMUS (*Corda.*)—Cells elongated, attenuated, entire, fasciculated. Cells fusiform or crescent-shaped, with no constriction. They resemble *Closterium*, except in their aggregation.

A. *falcatus* = *Xanthidium* (?) *difforme* (Ehr.)—Cells very minute, slender, crescent-shaped, fasciculated in irregular bundles, the individuals of which, having their convexity turned inwards, diverge at each extremity of the bundle. Length of cell 1-549th. (P. 2. f. 3; and P. 12. f. 513. 514.); the two latter fossil specimens.

A. *fusiformis* (Corda.)

A. *convolutus* (Corda.)

Genus PEDIASTRUM (Meyen.)—Frond plane, circular, composed of several cells, which form by their union a flattened star, and are generally arranged either in a single circle, or in two or more concentric ones; marginal cells bipartite. The cells are combined into a frond by a mucous matrix, which is generally colourless and constitutes hyaline interstices.

"The flat star-like fronds of *Pediastrum* are sufficiently characteristic. It is far more difficult to distinguish its species. Ehrenberg relies chiefly on the number of the circles, but this character cannot always be depended on; for it has been observed that the number of cells is in the same species liable to great variation; so also are the number of circles, and the number of cells in the inner circle. Though so uncertain, we must still, for the most, depend on the above characters in discriminating between nearly allied species. Ehrenberg, having relied almost entirely on the number of circles, and the cells in each, has neglected the form of the cells, and, consequently, his species are intermixed· transition-states of some being referred to others."

The process of division takes place at the notch, as in other *Desmidieæ.*

M. Thuret has recently advanced the statement, founded on his personal observation, that the fronds of *Pediastrum ellipticum* develope within their cells exact but minute copies of themselves; which, in course of time, assume the size and all the characters of the parent. He says, "all doubt was removed from my mind, when I witnessed the escape of four young ones from the cells of an old frond: the cells opening and emitting by degrees, often by jerks, the young *Pediastrum*, enveloped in its gelatinous mass." (Ann. des Sciences Nat. 1850.)

The old cells are left empty and colourless. In fronds not very young, a clear nucleus, refracting light strongly, was discernible; in the very young, this is not visible, and in the old fronds very indistinct. M. Thuret believes it to be concerned in the formation of the cell, or the reproduction of the species.

This method of development (M. Thuret remarks), recals that of *Volvox globator,* and of other Infusoria; and is probably without analogy among plants, (with which I reckon *Pediastrum.*) See observations of Weiss on *Chlorogonium euchlorum*, p. 192.

Ehrenberg has named this genus *Micrasterias*, who characterizes it thus—by their members being free, by their having a simple compressed lorica, composed of one piece, and grouping themselves together in definite numbers, in the form of a flattened star. The latter generic character arises from incomplete self-division when they are young, like Gonium. Projection organs of locomotion have not been observed, though slow change of place has been noticed. Numerous vesicles, analogous to polygastric digestive cells, are seen in several species; ova-like green granules are abundant; and Ehrenberg states he has seen glandular bodies which periodically increase in size, and are analogous to the seminal glands of other Infusoria. The dispersion of the ova has been seen by Turpin and Meyen, though it was regarded by them as that of the fecundating matter of plants. Dr. E. appends the following observations to the genus:—

"1. The relations of number observed in Micrasterias appear to form a firm character of the species (as in Gonium pectorale.)

"2. The relations of size are not always in ratio with those of number; for we find small size with a large number, and great size with a small number of parts.

"3. Forms exhibiting equal relations of number to size, otherwise distinguish themselves in secondary and less important points, as in a slender or thicker form of cell, long or short horns, &c., &c.; conditions varying in almost every individual.

"4. Of the numerous forms seen by me, all were two-pointed, none had one-pointed bodies. (No Pediastrum simplex.)

"5. Regularity of form is the character of integrity from irregularity; no distinct species can be formed." (P. 2. f. 114 to 117, 121 to 123, and P. 13, figs. 22, 28, and 29, illustrate this genus.) Mr. Ralfs divides *Pediastrum* into five sections.

* *Lobes of the outer cells emarginate or truncate.*

Pediastrum *tetras* = *Micrasterias tetras*, (Ehr.)—Cells four, separated by colourless interstices which form a cross; lobes truncato-emarginate. Frond extremely minute. Length of cell 1-2941th. (P. 13. f. 27.)

P. *heptactis* = *Micrasterias heptactis* (Ehr.)—Cells seven; six disposed in a circle around a central one; cells bipartite, with emarginate lobes. Length of cell 1-2906th. (P. 2. f. 114.)

P. *biradiatum* = *Micrasterias Rotula*, (Ehr.) Outer circle generally of eleven bipartite cells, with bifid or emarginate lobes.

Var. (*b.*)—Lobes of outer cells truncato-emarginate.

The five-angular cells forming the inner circle are often quadrilateral, and the exterior of each has a linear notch. Length of cell of outer circle 1-2000th.

** *Lobes of the segments entire.*

† *Connecting substance coloured.*

P. *Selenæa* = *Micrasterias Boryana* (Ehr.)—Cells crescent-shaped, arranged in one or more circles, around one or two central ones; connecting medium coloured. Frond minute.

† † *Interstices of the frond hyaline.*

P. *simplex.* = *Micrasterias coronula* (Ehr.)—Cells four, with or without one or two central ones; lobes of marginal cells ovate, tapering to a point.

Var. (*a.*)—Marginal cells truncate at the base and forming a circle, its centre vacant, or occupied by one or two cells.

Var. (*b.*) *cruciatum.*—Cells angular at the base, connected in a cruciform manner without a central space.

Pediastrum *pertusum.* = *Micrasterias Boryana* and M. *tricyclia* (Ehr.)—Inner cells leaving hyaline intervals resembling foramina; outer cells rectangular; notch triangular, as broad as the cell. Frond of from one to three circles arranged round one or two central ones. The number of cells, as in P. *Selenæa* and P. *Boryanum,* generally consists of five in the first circle, ten in the second, and fifteen in the third; but Mr. Ralfs has seen fronds with four cells, forming a circle around two central ones.

P. *granulatum.*—Cells granulated; lobes of marginal cells tapering Frond of six cells arranged around two central sub-quadrate ones.

P. *Napoleonis.* = *Micrasterias Napoleonis* (Ehr.)—Six angular cells, forming a circle around two central ones; lobes of marginal cells arspidate; notch wide. If not a variety of P. *Boryanum*? (P. 2. f. 117, 118.)

P. *angulosum,* = *Micrasterias angulosa* (Ehr.)—Marginal cells with angular lobes, which are not extended into rays; interstices hyaline. Frond minute, of one or more circles around a single central one. The inner cells are angular, as in P. *Boryana* and P. *ellipticum,* but the marginal are less deeply notched, and the lobes nearly angular, not in the least extended into processes or rays.

P. *Boryanum.* = *Micrasterias Boryana* (Ehr.)—Cells in one or more circles around one or two central ones; marginal cells gradually tapering into two long subulate points; notch narrow. (P. 2. f. 115, 116.)

It differs from P. *ellipticum,* in the gradually tapering acute lobes of the outer cells; from P. *angulosum* in its lobes being elongated as rays.

P. *ellipticum* = *Micrasterias elliptica* (Ehr.)—Cells variable in number and arrangement; lobes of marginal ones suddenly contracted into short, cylindrical, obtuse processes. Frond large.

Var. (*b.*)—Processes of the lobes truncato-emarginate.

P. *senaria* (Ehr.)—Cells in two concentric circles around one in the centre; twelve cells in the outer and six in the inner circle. External cells without appendages.

The two following new genera by M. Corda, are here introduced, as they appear allied to Mr. Ralfs genus Pediastrum.

Genus Asterodictyon (Corda.)—Compound; made up of many, but

yet a definite number of corpuscles cells, forming a membranous polypary (compound frond.) The frond is flat, stellate, multi-locular, and reticulate; and each of its corpuscles has its margin extended into a tubular and pervious horn. *Asterodictyon* has a general resemblance to *Monactinus* and *Pediastrum*.

ASTERODICTYON *triangulum*.—The smooth triangular corpuscles are combined in triple series, and form a stellate disc. This compound star has its centre void, with an innermost row of five, a middle of ten, and a marginal of fifteen to sixteen cells. Diameter of each frustule 1-1080th.; of the entire star 1-216th. Near Berlin.

A. *ovatum*.—Corpuscles granular, ovate, terminated by a long style, and arranged in two concentric circles, forming a star: three cells form the inner row, and ten the outer. Diameter of each 1-780th., of the entire star 1-312th.; near Berlin. These forms, when sometimes irregular by monstrosity, very closely resemble the *Monactinus simplex* and M. *acutangulus*, of Corda.

Genus MONACTINUS.—Compound; corpuscles numerous, connected so as to form a membranous polypary (frond) flat, stellate, multilocular, not reticulate, and having its cells in a single circle. Each cell terminated by a solitary style (with a single aperture.)

Pediastrum, which most nearly resembles it, differs in its forked or bidentate cells (and in its double aperture.) Ehrenberg believing in the animal nature of the *Desmidieæ*, the apertures are important to his view.

M. *simplex* (Corda.)

MONACTINUS *acutangulus* (Corda.)

Genus SCENEDESMUS (Ralfs.)—Frond composed of two to ten fusiform or oblong cells, arranged side by side in a single row, but after division in two alternating rows; division oblique. Cells entire; in some species the outer ones are lunate. There is no constriction or suture at the middle, and the endochrome is not divided into two portions by a transverse band. The division of the cells is oblique, and not transverse, as in most genera of the *Desmidieæ* and as they all divide simultaneously, two rows are produced, which are held in opposition some time after division is complete, by the connecting hyaline matrix.

The endochrome is, in general, very pale, and the starch granules

are inconspicuous. *Scenedesmus* differs from the preceding genera in the very different form of its cells, but *Pediastrum* supplies a connecting link between them. As in that genus, the frond in *Scenedesmus* is composed of several cells, but these are differently arranged; and the division into two segments, which, although modified, is still met with in the outer cells of *Pediastrum*, is entirely absent in *Scenedesmus*. In the oblique manner in which its cells divide, it agrees with *Spirotænia*, which, however, has a different arrangement of the endochrome, and a frond consisting merely of a single cell.

SCENEDESMUS *quadricauda* = *Arthrodesmus quadricaudatus* (Ehr.)—Cells, generally four, oblong, rounded at their ends, disposed in a single row; each extremity of the two external ones usually terminated by a bristle (P. 13, f. 19 and 36.)

Var. *(b.)*—External cells with three bristles.

Var. *(c) ecornis* = *Arthrodesmus ecornis* (Ehr.)—All the cells similar and without bristles. Length of cell 1-1121st. Breadth 1-2631st.

S. *dimorphus* = *Arthrodesmus pectinatus* (Ehr.)—Cells acute, four to eight placed evenly in a single row; the inner cells fusiform, the outer externally lunate. Frond very minute. Length of cell 1-1026th to 1-906th. Breadth 1-8160th.

S. *acutus* = *Arthrodesmus acutus* (Ehr.)—Cells two to eight, fusiform, acuminate, arranged in a single, irregularly alternating series. The two outer cells are frequently crescent-shaped. Length of cell 1-1063rd to 1-1020th.

S. *obliquus*.—Cells eight, elliptic-fusiform; after division arranged in two distinct, generally oblique series, the outermost cell of each not in contact with any of those in the other series.

S. *obtusus*.—Cells three to eight, ovate or oblong, and arranged in one row, or, after division, alternately in two rows. Frond minute. Endochrome very pale green.

This species is rarely met with in a simple state, but, as the cells after division are retained in connection by the mucous matrix, two rows are usually present, the broader ends of one row lying between the cells of the other. The hyaline matrix is frequently their only bond of union, and in this state they seem to connect the *Desmidieæ* with the *Ulvaceæ*, through *Merismopedia*.

SCENEDESMUS *duplex.*—Cells slender, fusiform, sigmoid, tapering at each end into a fine point; after division, closely connected for about half their length.

S. *antennatus.*—Cells fusiform, somewhat ventricose at the middle; ends cuspidate. each terminated by a minute orbicular globule.

The description of these genera, and some others since established by Ehrenberg, as also that author's characters of *Odontella,* will conclude this section.

Genus SPHAERASTRUM. *The round star Animalcules* are characterized by their members being free, having a simple univalved smooth and turgid lorica, and by forming, during self-division, different shaped groups. A slight change of place or locomotion has been observed, but little or nothing of their organization is known, though Bory and Turpin have stated the existence of male seminal glands in S. *quadrijuga.*

S. *pictum* has oval green corpuscles, passing into spherical clusters, of the form of a mulberry. Size of berry 1-480th; of single member 1-1920th. Found with Micrasterias.

S. *quadrijugum* has oblong green corpuscles, four being united into cubical mass, perforated at the middle. Size of berry 1-570th; of single member 1-1200th. Found with the former species.

Genus MICROTHECA. *The spinous disc Animalcules.* It contains only one species, and is characterized by being free, and possessing a simple square compressed lorica, composed of one piece. In its organization it approaches that of *Gallionella* and *Achnanthes.*

This genus is a very doubtful member of the *Desmidieæ.* It presents no indication of the characteristic division into two valves; and the golden colour of its only species, is a character of *Diatomeæ,* and, consequently, an argument against its being one of the *Desmidieæ.*

M. *octoceros* has a square transparent lorica, with spines, (P. 2, f. 119, 120, the first a front, the latter a side view.) It is of a golden colour, variegated; change of place has not been observed. "I received," says Ehrenberg, "in September, 1832, phosphorescent sea-water, from the harbour of Kiel. On the 23rd of October I found therein this yellow creature, which appeared very similar to

a specimen of *Anuræa,* which, together with yellow phosphorescent species of *Peridinea,* were living in the same water; but no direct evolution of light was observed from M. *octoceros.*" Size 1-280th without the spines; with the spines 1-210th.

Genus Lithodesmium.—Lorica simple, univalved, siliceous, and triangular in shape. Self-division imperfect, the creatures being clustered in the form of straight and rigid triangular-shaped wands; cluster unattached.

This genus was named and described by Ehrenberg, in 1840, as belonging to the family *Desmidieæ*; however, this alliance would, from the illustration given, appear very doubtful.

L. *undulatum.*—Corpuscles large, smooth, and pellucid; the angles obtuse. Two of the sides are undulated, the others doubly excised; openings and motion are not perceptible. The corpuscles are somewhat longer than they are broad. Found alive, in sea-water, at Cuxhaven. Greatest length of corpuscle, 1-480th. (P. 13. f. 41, 42.)

Genus Eucampia.—Lorica univalved, wedge-shaped, and flat, excised in the middle of its lateral surfaces. Self-division being imperfect, the creatures are clustered in the form of flat articulated chains, having roundish holes between adjoining segments, the curved chains gradually becoming circular; cluster unattached. This is another questionable genus of *Desmidiacea,* described by Ehrenberg in 1840.

E. *zodiaca.*—Lorica crystalline, smooth, a little longer than it is broad; ova of a light yellow colour. Locomotion not perceptible. Found alive in sea water, at Cuxhaven. Diameter 1-1150th. (P. 13. f. 43.)

Genus Odontella (Ehr.)—*The tooth-chained Animalcules* comprised in this small genus are unattached and free, having a simple univalved compressed lorica, and multiply by an incomplete spontaneous self-division, in the form of flat articulated ribbons or chains; each link of such chain-like bodies is composed of a single pair united, which are connected with the next pair by two processes, a small space being left between them (see f. 108), and hence they differ from the genus *Desmidium.* The internal coloured granular matter is

probably ova, and the three vesicles in O. *filiformis*, stomach cells and fecundating glands. In O. *unidendata*, the glandular body is very distinct from the digestive sacs. (See Odontella in next section.)

Odontella *desmidium*.—Space between the processes of each pair distinct. (see f. 108.) Size 1-1150th. to 1-570th. (See page 242.)

O. (?) *filiformis*.—The two slender processes connecting each pair leave a square space between them. (f. 107. See page 243.)

O. *unidentata*.—Oval binary corpuscles, often irregular; they are connected by a single process in the middle. (See page 243.)

Genus Gymnozyga (Ehr.)—Generic characters assigned to it by Ehrenberg, unknown.

G. *moniliformis*.—Corpuscles ovate, concatenate, forming a filament, furnished with a median sulcus like that of *Gallionella*, with a soft, not siliceous integument; and, after the manner of the *Conjugatæ*, two corpuscles coalescing and producing another individual by their zygosis, or conjugation. Diameter 1-1150th. Common in the marshes of Berlin. (vide Didymoprium Borreri.)

Genus Polysolenia (Ehr.)—Generic characters unknown.

P. *closterium*.—Corpuscles very large, obtusely fusiform, straight or slightly lunate; thick, green, and smooth; at a later period hyaline cirrhose on every side. Length 1-60th. to 1-48th. Berlin.

Has the habit of *Closterium acerosum*, whose structure it entirely resembles, except that, at certain periods, very many (to the number of fifty) cirrhi shoot out from as many apertures, not before visible, and seem to withdraw, in their exit, the internal green mass.

This account appears like a misconception of some phenomenon, such as the germination of a spore, or the growth of mycelium on a *Closterium*, according to Mr. Ralfs it is = *Penium digitus*.

Genus Zygoxanthium (Ehr.) — Generic description wanting. Ehrenberg has most probably instituted *Zygoxanthium* as a sub-genus of *Xanthidium*.

Z. *echinus* = *Xanthidium echinus*, 1839.—Corpuscles (segments, Ralfs) globose, single and in pairs, aculeate, aculei thick, short, forked at the apex, or trifid; and provided on the sides with two median tubules, having a stellate orifice: contents (ovaria Ehr.) green. Diameter of a single corpuscle 1-480th. Internal granules

often seem in motion. Two corpuscles unite by *Zygosis* (*i. e.* conjugate) and produce, between them, a smooth, globose young one.

Genus Triploceras (Bailey.)—Frond binate; segments straight, much elongated, with numerous whorls of knot-like projections; ends of the segments three-lobed; lobes bidentate. A genus closely allied to *Docidium*, differing in the three-parted ends of the segments.

T. *verticillatum* (Bailey) = *Docidium verticillatum* (Ralfs.)

T. *Gracile* (Bailey.)—Slender, with whorls of rounded projections.

Section II.—Naviculacea.

This section, together with the *Echinellea*, and the *Lacernata* of Ehrenberg, are equivalent to the *Diatomacea*, *Diatomeæ*, or *Cymbelleæ*, of other authors. In the following observations on structure, habit, &c., it is proposed to comprehend all the forms of *Bacillaria*, exclusive of the *Desmidiacea.*

The individuals of the *Diatomeæ* are variously spoken of as testules (*testulæ*) or frustules; and also, when forming members of a compound band, chain, or filament, or of other aggregated mass, as—segments, corpuscles, and sometimes loricæ. But the term lorica, though often used as equivalent with frustule, rightly expresses merely the exterior coat, or shell which determines the form of the individual, and is in this section always siliceous.

This lorica, in its multiplied and often very beautiful forms, consist sof an outer clear or hyaline, colourless, siliceous coat, and of an inner more or less coloured one, considered to be of a softer and more organic constitution. Nägeli supposes a mucilaginous film to exist on the inside of this second coat: and Kützing also speaks of a third element, displayed when recent frustules are dried, and especially after their having been heated to redness, as an opaque or brownish space, extending itself, not unfrequently, over a considerable portion of the lorica. To this material the name of cement is applied by Kützing, as he supposes it to be the connecting material of the valves or portions of the lorica, and also of frustules when united.

Its brown colour he would attribute to the probable presence of iron in its chemical composition.

Two views have been advanced relative to the origin of the external siliceous lamina; one, that the silex exists in intimate union with the cell, whose wall is believed to consist of cellulose penetrated with silica; the other, that the siliceous valves are deposited *exterior* to a cell-membrane. (Smith, Ann. Nat. Hist. 1851.) Nägeli says, "This es outside the membrane, and must be regarded, from analogy to all other similar structures, as extra cellular substance excreted from the cell" (Ray Society, 1846, p. 220.) But apart from analogy, Mr. Smith states he has direct evidence of the independence of the siliceous coat, having in his possession numerous specimens of A. *Stauroneis* (probably of S. *aspera*, Kütz.), in which the valves, after a slight maceration of the frustules in acid, have, in part or wholly, become detached from the cell-membrane, leaving a scar on its walls, bearing the distinct impression of the numerous and prominent valvular marking of this beautiful species." Still more recently, Prof. Bailey, of New York, states, that if hydrofluoric acid is applied to recent, or even sometimes to fossil *Diatomacea*, the shell soon dissolves, leaving distinct internal, flexible cell membranes, retaining the general form of the shells.

This second view of the separate existence of the inorganic siliceous tunic, and its origin from the organic internal membrane, appears therefore the true one, from the preceding facts, and it is still further supported by the phenomena of self-division of the frustules; for in this process the lining cell-membrane takes the initiative, and is followed by the doubling of the external coat upon it, as an after production.

Ehrenberg states the lorica to be composed of two or more pieces or valves; Mr. Ralfs says, "it consists of three pieces, one central and ring-like, or continuous all round, and the other lateral;" but the investigations of the Rev. W. Smith would go to prove, that, in not a few instances, the central ring-like segment is not an essential one, but only developed when self-division is proceeding. In some of the anomalous genera of Ehrenberg, as *Dictyocha*, the individual would seem to be composed of several pieces, varying in number in various species.

The siliceous external coat is often very beautifully sculptured; the markings being modelled on the living organic membrane. Much discussion has arisen as to the true nature of these markings, which assume the appearance of dots *(puncta)*, ribs *(costæ)*, striæ, pinnules (pinnæ), furrows, or lines—whether the dots are actually pores, as generally surmised by Ehrenberg, and whether the ribs, striæ, or lines, are depressions or elevations of the surface, or even sometimes figures. The opinion seems to be gaining ground, that the lorica is entire without pores or fissures; in favour of this opinion, are Ralfs, Nägeli, Dujardin, the Rev. W. Smith, and Schleiden. On the contrary, Kützing supposes the gelatinous investment of many *Diatomeæ* to issue from pores in the lorica; and Ehrenberg believes in the existence of both pores and fissures, supposing the former to give exit to organs of locomotion and the latter to ova, &c. (See genus *Navicula*, and plates 19 and 20.) In several genera, for example, *Eupodiscus, Cerataulus, Rhizoselenia*, &c., the lorica produces more or less extended processes, simple or branched (ramose), which are generally known as *cornua*, sometimes as *tubuli* (Ehr.) It often happens that the apparent lines, or bands, on the surface, are merely indications of internal partitions (septa), and which are either complete or perfect (*i. e.*, entirely dividing the internal cavity of the lorica), or incomplete (imperfect.) To the partial septa, as in *Grammatophora*, Kützing has assigned the term *vittæ*. "The lines," says Nägeli, speaking of a form allied to *Gallionella* (Ehr.) "which would intimate a division of the shield into two or more pieces, are the septa by which the cell-division is effected."

The puncta, costæ, and other external markings, as also the processes of the lorica, are valuable in forming specific and generic characters. The presence or absence of a central pore often forms a leading characteristic. Kützing, indeed, rests his great division of the *Diatomeæ* into *Stomaticæ* and *Astomaticæ*, on this peculiarity.

The distinctness of the various markings of the lorica is much interfered with by the presence of the lining membrane, which should therefore be destroyed by maceration in nitric acid, or by exposure to a strong heat.

The cavity of the lorica, in the true *Diatomaceæ*, is now generally admitted to be single; in other words, their frustules are uni-cellular.

In the *Naviculæ*, Schleiden believes he has proved this by direct observation. Mr. Ralfs, indeed, states, that, in *Navicula* and other genera of *Diatomaceæ*, the frustules are often truly binate, but we question whether they are actually so, except when fission is proceeding. Throughout his learned essay on the cell-nucleus and cell-formation, Nägeli treats of the *Diatomaceæ* as uni-cellular organisms.

Each frustule generally presents four sides, or planes, which, unfortunately, have been variously designated. Ehrenberg has used the terms *dorsum, venter*, and *lateral surfaces* or *sides*, but which do not in all instances represent homologous surfaces. Oftentimes he has called a convex surface, simply on account of its convexity, the *dorsum;* and a concave one, from its concavity merely, the *venter*, or ventral surface.

Kützing has endeavoured to amend this nomenclature, by calling those sides which have no central opening, but through which self-division occurs, the *primary sides;* and the other two, the *secondary sides*. These secondary sides are further distinguished into right and left, when the frustule lies on a primary side. The left is often concave, and the right convex, but mostly the two are alike. As a general rule, the primary sides correspond with the so-called *lateral surfaces* of Ehrenberg, and the secondary sides, respectively, with the dorsum and venter of that author.

The Rev. W. Smith has the following remarks on this subject, which illustrate the usage of most English writers: "Late writers have found, in the process of self-division, circumstances to fix the terminology applied to the Diatomaceous frustules, and use the words 'primary sides,' when speaking of those portions where the interposition of the new half-frustules occurs; the term secondary sides being applied to the general surface of the valves; others employ the words *front* and *lateral view* in the corresponding senses. I shall adopt the latter terms as more generally applicable; the *primary side*, as employed by the writers alluded to, frequently including portions of the frustule which belong to the secondary surfaces, brought into view by the convexity of the valves. . . . . . With Mr. Ralfs, and other English writers, I would use the term *front view* to denote the aspect of the frustules, when the connecting membrane and

valvular suture are turned towards the observer; the words *lateral* or *side-view*, when the general surface of one of the valves is directed to the eye."

When any two opposite surfaces approximate about the margin of a frustule, the other two sides are reduced to so narrow a band as to be virtually obliterated, and are then spoken of as *obsolete*.

Within the lorica is contained the living substance of the frustule, regarded by Ehrenberg as forming definite animal organs, viz., stomachs, ovaries, and ova, seminal glands and vesicles. But all such animal organs are ignored by other naturalists; and the contents generally are known as the *endochrome*, whilst the particular vesicles and granules are represented as similar to the like formations in the Confervæ, and as constituted of chlorophyll, starch, and mucilage. The number and position of these vesicles vary in individuals of the same species; sometimes, indeed, specimens occur with no vesicles (stomach-sacs of Ehrenberg); and further, a circulation or rotation of the contents of the cell has been observed by Nägeli in a *Gallionella*, and by Rev. W. Smith in *Surirella*. Some of the clear vesicles, Kützing has concluded to be oil particles; and affirms, that he has occasionally seen two coalesce, proving the absence of proper walls. The entire endochrome that author also has designated the *gonimic* substance.

The prevailing colour of the endochrome of *Diatomeæ* is golden-yellow or brownish; very rarely green, except when the frustules are dried.

According to the researches of Nägeli, the *Diatomeæ* present, generally, among their other contents, a *nucleus*, which in some genera is free (isolated) within the general cavity, or parietal—affixed to the walls, as happens in *Gallionella*. This special organ plays a very important part in the phenomena of cell growth, and, in the opinion of Schleiden, precedes and brings about the formation of the cell-wall enclosing it. Nägeli makes two sorts of nuclei, *primary* and *secondary*, attributing to the former the same properties as does Schleiden in the original formation of the cell, and in its subsequent multiplication by self-division. In the latter process, the nucleus is supposed first to double itself, and then the septum to appear, which ultimately halves the frustules.

Nägeli further describes the cell formation in *Diatomaceæ*, as taking place around the whole contents of the parent cell: that "during the production of the septum, the secretion of gelatinous matter continues over the whole surface of the cell contents. The production of the septum itself may be thus explained: the contents separate into two parts, each becoming invested with a membrane, which appears as a thin wall between them, but is actually composed of two lamellæ."

Our space, and the nature of the treatise, forbid entering more largely on this interesting but much vexed question of the nuclear development of cells. Those readers who desire to follow up the subject, cannot do better than study the learned disquisition by Nägeli on cell-formation, quoted in the preceding pages.

The Rev. W. Smith has given the following succinct account of the process of fissiparous, or self-division: "At first, the siliceous valves (as seen in front view) are in close contact at their suture (P. 18, f. 20), but their adherence is speedily disturbed by the dividing process which these minute organisms are constantly undergoing. The first step in this process is the gradual separation of the valves, an effect apparently produced by the expansion of the internal membrane. *Pari passu* with the retrocession of the valves, the cell wall exposed between their edges is being covered with a deposit of silex, and the frustule now consists of two symmetrical valves, united by a plate of silex (P. 18, f. 23) which either forms a continuous ring (P. 18, f. 22) or consists of two portions united at the extremities of the valves. This plate, with the underlying cell-wall, may, for the sake of distinctness and future reference, be termed the connecting membrane.

"When the connecting-membrane has been formed of sufficient width, the original cell, probably by the doubling in of its wall, becomes divided into two, and immediately secretes, at the line of division, two new siliceous valves, symmetrical with, and closely applied by their edges to the original halves, and thus the self-division is complete, and two perfect frustules have been the result. (P. 18, f. 20.)

"In some cases, by the new or rather semi-new frustules immediately proceeding to repeat the process, the connecting-membrane is

thrown off and disappears; in others, it remains for some time linking the frustules in pairs, as in *Melosira* and *Odontella;* and sometimes it is only partially torn away or absorbed, and unites the frustules successively formed in a zig-zag chain, by portions remaining attached to their angles, examples of which we find in *Diatoma, Isthmia,* &c. (Ann. Nat. Hist. 1851 p. 4.)

"There appears, however," says Mr. Thwaites, "a limit to this mode of propagation of the frustule, except by the intervention of another phenomenon — viz., conjugation, or a mixture of endochromes; after which process, fissiparous division proceeds as before." (Ann. Nat. Hist. 1848, p. 161.)

Moreover, self-division is an act only of *multiplication*, physiologically speaking, for all the frustules so produced, are but parts of the original individual producing them,—of that one which derived its individuality from a sporangium, the result of conjugation, which is a process of actual propagation.

The elucidation of this wonderful phenomenon of conjugation in the *Diatomaceæ,* we owe to Mr. Thwaites; from whose papers we shall endeavour to give a condensed account of it.

For the most part, conjugation in the *Diatomacea,* as in the *Desmidieæ,* consists in the union of the endochrome of two approximated fronds, this mixed endochrome developing around itself a proper membrane, and thus becoming converted into the sporangium. In a very early stage of the process, the conjugated frustules, as in *Eunotia turgida,* have their concave surfaces in nearly close apposition (P. 14, f. 1) and from each of these surfaces two protuberances arise, which meet two similar ones in the opposite frustule (P. 14, f. 3); these protuberances indicate the future channels of communication by which the endochrome of the two frustules becomes united, as well as the spot where is subsequently developed the double sporangium, or rather the two sporangia. A front view of two frustules at the same period, shows each of these to have divided longitudinally into two halves (P. 14, f. 4.), which, though some distance apart, are still held together by a very delicate membrane; that, however, soon disappears.

The mixed endochrome occurs, at first, as two irregular masses between the connected frustules, but these masses shortly become

covered, each with a smooth, cylindrical membrane — the young sporangia, which gradually increase in length (P. 14, f. 5, 6) retaining nearly a cylindrical form (P. 14, f. 7) until they far exceed in dimension the parent frustules, and, at length, when mature, become, like them, transversally striated upon the surface (P. 14, f. 8.) Around the whole structure a considerable quantity of mucus has, during this time, been developed, by which the empty frustules are held attached to the sporangia (P. 14, f. 5 to 8.)

In the immature condition, it happens that the sporangia, in many species, resemble in general characters the mature frustules of another species, or even of an allied genus. Thus the sporangia of *Gomphonema minutissimum*, and of G. *dichotomum*, have a close resemblance to frustules of *Cocconema*. On the other hand, in some genera, as in *Cocconema*, the sporangia take on at once the exact characters of the ordinary frustules, from which they differ only in their exceeding that of the majority of the latter in dimensions.

When a sporangium in a transitional condition is like the frustule of another genus, we are assisted in distinguishing its true nature and affinity, oftentimes by the persistence of the mucus diffused around it; or, by continued observation, we may witness its assumption ultimately of its true specific characters, including the development of its pedicle or stalk, where the possession of such an organ is a characteristic (as in *Gomphonema*.) The development of the sporangium being complete, it enters on an independent existence, which it displays by undergoing fissiparous division, as in common frustules.

It is very probable that transitional forms have been described as particular species, or located in wrong genera. Thus, Mr. Thwaites thinks that Kützing's *Epithemia Vertagus* is the sporangium of *Eunotia turgida*.

In different genera, slight variations are met with in the method of conjugation: thus, in some species of *Gomphonema* the sporangia lie in a direction parallel to the empty frustules, instead of across them, as described in *Eunotia turgida*. Again, there are examples (in *Gomphonema minutissimum* and *Fragilaria pectinalis*), where, instead of the conjugated frustules separating into two halves, only a slit appears at one end, to serve for the escape of the endochrome.

Instead, also, of the pair of conjugated frustules producing between them two sporangia, they may develope but a single one, as happens in *Fragilaria pectinalis*. In this species, too, the sporangium, at first cylindrical, soon assumes a flattened, somewhat quadrangular form, and, in many cases, undergoes fissiparous division before it has put on the exact appearance of the frustule of a *Fragilaria*.

"The *Meloseiræ* (*Gallionella*, Ehr.), and the *Biddulphiæ*, (Mr. Thwaites remarks), would seem, in their development of sporangia, to offer an exception to most *Diatomaceæ;* for in those genera no *evident* conjugation has been seen. However, something analogous to it must take place; for, excepting the mixture of endochromes of two cells, the phenomena are of precisely similar character. Thus, instead of the conjugation of two frustules, a change takes place in the endochrome of a single frustule,—that is, a disturbance of its previous arrangement, a moving towards the centre of the frustule, and a rapid increase in its quantity: subsequently to this, it becomes a sporangium, and out of this are developed sporangial frustules, as in the other *Diatomaceæ*. In a single cell, therefore, a process, physiologically precisely similar to that occurring between two conjugating cells, takes place; and it is not difficult to believe, taking into view the secondary character of cell-membrane, that the two kinds of endochrome may be developed at the opposite ends of one frustule, as easily as in two contiguous frustules, and give rise to the same phenomena as ordinary conjugation." In the *Zygnemeæ*, adjoining cells in the same filament are found to conjugate.

The process of conjugation has now been seen in most genera of the well-defined *Diatomaceæ*. Observed first in *Eunotia*, it was subsequently seen in *Gomphonema*, *Cocconema*, *Fragilaria*, *Schizonema*, and its modified character in *Melosira* and *Biddulphia*.

Kützing, unacquainted, at the time his treatise was written, of propagation by conjugation, considered that the *Diatomeæ* multiply in three ways:—1. By development of their gonimic substance (endochrome) which, as he says, happens in the lower Algæ, but in the *Diatomeæ* is uncertain. 2. By fission, complete, or incomplete, a general mode; and 3. By gemmæ or spores, the formation of which he has witnessed in several species of *Melosira*, in *Schizonema*, and in *Micromega*.

Are the *Diatomacea* plants or animals? is still a *questio vexata.* The able discussion of this point by Meyen, in the case of the *Bacillaria,* generally, is given in the previous pages; and here is appended a summary, by Kützing, of the arguments urged on each side in the case of the *Diatomeæ.*

"For their animal nature, Ehrenberg presents the following arguments.

1. The *Diatomeæ* exhibit, in part, a peculiar spontaneous movement, which is produced by certain locomotive organs.

2. The greater part have in the middle of the lateral surface an opening, about which round corpuscles are situate, which become coloured blue when placed in water containing indigo, like as do the stomach-cells of many Infusoria, and, consequently, they may also be regarded as stomachs.

3. The shells of many *Diatomaceæ* resemble, in structure and conformation, the calcareous shells of *Gasteropoda,* and similar *Mollusca.*

Of the *first* argument, it may be observed, that spontaneous motion is met with also in the lower plants, in which, moreover, it arises from special ciliary locomotive appendages. I would instance the observations of Unger on *Vaucheria clavata.* . . . . . of Flotow on *Hematococcus pluvialis,* and lastly my own (in the *Phycologia generalis*) on *Ulothrix zonata,* and other Algæ; all which shew that in these lower organisms evident movements occur, not to be distinguished from those of the Infusoria.

Hence this argument fails.

As to the second position; the colouring of the so-called stomach-cells by indigo, as I have before proved, is probably but a mechanical operation; and affords no evidence of their stomach-like character, and especially as the vesicles are often wanting.

Of the third argument. The shell has frequently, indeed, in structure, conformation, and markings, a similarity to that of *Mollusca,* but this is not invariably the case, and we find among the cells of higher plants, those which, in configuration, form, and other particulars, exhibit similar appearances. For instance, the numerous forms of pollen, with their angles, spines, orifices, &c. In this matter, relation of form, therefore, the *Diatomeæ* stand as closely to vegetable as to animal structures.

On the other hand, the following facts are in favour of their vegetable nature:—

1. The great resemblance of compound forms to Algæ, and their development by fission. There are, indeed, compound Infusoria, as Monad-masses and Polypes, but the former are very questionable animals, and the latter have this essential distinction, that the individual animal lives without (external to) its habitation, and moves freely; whereas such *Naviculæ* as *Encyonema*, *Schizonema*, and *Micromega*, and similar genera, grow within the enclosing substance, building themselves up like the cells in the stem of a plant, so vegetating here only as cells. In like manner, the individuals of *Fragilaria*, *Melosira*, *Himantidium*, &c., are steadily fixed, and unable to exhibit animal motion.

2. The inner soft, organic parts, which I have designated gonimic substance, possess, as well in their chemical nature as in their development, peculiarities akin to those met with in the cell-contents of confervoid Algæ.

This relation is most clearly seen in the genus *Melosira* and its allied forms, which, not only in form, but also in the chemical components of their contained matter (since the presence of chlorophyll is common to all *Diatomeæ*), are closely allied to the confervoid Algæ.

3. The development of seeds, or young, (as Kützing represents it) occurs here as in undoubted Algæ, but never as in true animals.

4. The *Diatomeæ*, and especially the free, moving *Naviculæ*, develope, in the sun's rays, an appreciable quantity of oxygen, like all admitted plants.

The evolution of oxygen, indeed, occurs in green Monads and *Euglenæ*, but this affords no argument for the animality of the *Diatomeæ*, but renders the animal nature of those Infusoria themselves very doubtful; and the more so, as recent observations comfirm the idea of the origin of the lower plants themselves, from Monads and *Euglena*, (page 18.) Wherefore, all these comparisons serve to favour the belief in the vegetable nature of *Diatomeæ*, (Dickieselschaligen, Bacillarien oder Diatomeæ, Von Dr. F. T. Kützing, Nordhausen, 1844.) Some English writers have acceded to the opinion that the *Diatomeæ* are vegetables, from the above views

expressed by Kützing, and, above all, from the phenomenon of conjugation. This last, so much insisted on as a proof of their vegetable nature, has been already dwelt upon in this volume.

M. Thuret, in his late essay, expresses himself to the effect that there is no more reason in the favour of the one view than of the other. Schleiden, after describing the siliceous lorica, adds: "Such an artificial and complicated structure among plants has no explanation, and is entirely without signification. In all actual plants we find the silica present, in quite a different form, as little separate scales or drops, and distributed throughout the substance of the cell-wall." Professor Bailey's opinion is decidedly in favour of their being animals. (See page 217.)

In a geological point of view, the members of this great section are the most important of organized beings; for, although individually invisible, they exist in such countless myriads, that they form strata of great extent, and play a far more important part in building up the earth's crust, than the gigantic Saurians of past ages. The town of Richmond, in the United States, is built upon a stratum twenty feet in thickness, composed almost entirely of the siliceous shells of the *Naviculacea*. This is not an isolated fact. In Bohemia, at Bilin and Ægina, deposits of similar origin cover many miles of surface. In Sweden and other countries, shells of various genera abound. These organisms are found in the Pliocene, Miocene, Eocene, and chalk formations; indeed, even the Oolitic and older strata are not without traces of them; hence, although occupying the lowest place in the animal series, they form an extended base of a triangle, on which man stands at the apex. (See geographical distribution, &c., page 62.)

The study of these organisms in connexion with agriculture, has not been much attended to; so much, however, has been ascertained, as to render its importance undoubted. In Guano manure, the presence of shells of *Bacillaria* is not thought to add to its fertilizing qualities, but Dr. Bailey has shown that the great fertility of the rice fields of South Carolina is mainly due to them.

Diatomacea are very abundant, both in the sea and in brackish and fresh water; some genera are essentially marine, others peculiarly of fresh water habit.

In pure river or spring water these little beings are not found; but on the banks of rivers and ditches, about the source of springs, and also in gutters and moist places generally, they are abundant.

The fine fibrous Algæ, marine and freshwater, are often richly clothed with them, sometimes indeed completely overgrown by them. They are common, too, in summer, in small ponds, and in the mud on the sides of ditches, and, when numerous, impart a brown colour. On warm summer days, they are often raised to the surface by the oxygen gas they generate, and which adheres to them, when they form thin, delicate films on the surface, and sometimes a layer of greater thickness, mucous and compact. Otherwise, they occur in aggregated, intricate masses. The microscope shows the thin pellicle oftentimes made up of various species, mostly *Naviculæ*, *Cymbellæ*, *Surirellæ*, or free *Synedra*, congregated together, and having a more or less lively motion. The mucous and larger masses, generally have but one prevailing species.

The *Melosiræ* (*Gallionellæ*, Ehr.) build brownish, conferva-like masses, which affix themselves to plants, or stones, or other solid substances in the water; other forms, as *Fragilaria*, occur generally on decaying wood or leaves, or amongst Conferva, mingled with *Cymbellæ*, *Synedra*, &c. It seldom happens that one form is found alone. Larger specimens are mostly met with in aggregate, attached masses; smaller when isolated, free and moving about.

Brackish water, where a river discharges itself into the sea, or where the sea water rises with the tides and mixes with the fresh water of the stream, are localities in which *Naviculacea* abound. Such water, on being passed through a filter, leaves all its larger particles behind on the cloth, and these can be collected and prepared as may be required. When we have to deal with a film on the surface, it may be removed with a spoon or spatula, and placed on paper; where the frustules grow on Algæ, the two may be removed together.

In the case of fossil *Diatomacea*, which mostly occur mixed with various mineral particles, they may be separated for examination, as described in Part II. page 110.

The following very ingenious plan of getting transverse or oblique sections of the small loricæ of *Navicula*, and of other *Diatomeæ*, is

given by Schleiden, and is similar to the plan of making sections of hair for the microscope: "This may be done by taking some of the siliceous earth of Erbsdorff, and mixing it with mucilage, and, before it is perfectly hardened, cutting off delicate plates with a razor." (P. 18, f. 4) "exhibits a section of the upper part of a shield prepared in this way." (Principles Botany, page 594.)

Kützing offers the following arrangement of the *Naviculacea*, or, as he calls them, *Diatomeæ*. He objects to the systems of other naturalists, stating "that they have all one leading error: viz., that of assuming as their basis characters extremely variable, and scarcely to be employed in the identification of individual species,—such as the presence or absence of a gelatinous induvium, or of a stipes or pedicle; or the occurrence of the frustules solitary or concatenated."

On the other hand, the structure of the shells being constant, he has employed it in framing his arrangement, as follows: Tribe 1. *Striated Diatomeæ;* lorica siliceous, and either quite smooth or transversely striated on the secondary side, but never vittate or areolate (cellular.) Tribe 2. *vittate (striemige);* lorica siliceous (on primary side) longitudinally (rarely transversely) vittate, smooth or transversely striated, but never areolate. Tribe 3. *Areolate* (*Zellige*) *Diatomeæ;* lorica siliceous, secondary side areolate or cellular.

The accompanying tabular view displays the further division into orders and families, by Kützing, of the *Diatomeæ*.

Tribe I.—Striatæ	Order I, Astomaticæ. Without a central opening on the secondary side.	* Transverse striæ unbroken.	Family 1. Eunotieæ
			—— 2. Meridieæ
			—— 3. Fragilarieæ
		* * Striæ broken (interrupted) in the median line.	Family 4. Melosireæ
			—— 5. Surirelleæ
	Order II. Stomaticæ. With the central opening	*a.* MONOSTOMATICÆ. Having a median aperture on only one of the two secondary surfaces.	Family 6. Cocconeideæ
			—— 7. Achnantheæ
		b. DISTOMATICÆ. With a median aperture on each secondary surface.	Family 8. Cymbelleæ
			—— 9. Gomphonemeæ
			—— 10. Naviculeæ
Tribe II.—Vittatæ	Order I. Astomaticæ. Without median aperture on secondary side.		—— 11. Licmophoreæ
			—— 12. Striatelleæ
Tribe III.—Areolatæ	Order II. Stomaticæ. With a large distinct one.		—— 13. Tabellarieæ
	Order I. Disciformes		—— 14. Coscinodisceæ
			—— 15. Anguliferæ
			—— 16. Tripodisceæ
	Order Appendiculatæ, Appended and doubtful forms.		—— 17. Biddulphieæ
			—— 18. Angulatæ
			—— 19. Actinisceæ

In a recent volume, entitled "Species Algarum," Kützing does not give any tabular view of the *Diatomeæ*.

The arrangement of the numerous genera which compose this section of the family *Bacillaria*, presents many difficulties. Although much has been done of late, yet much remains to be done before a

permanent arrangement can be made according to their affinities. The improvements on the microscope have enabled us to discover markings on the shells previously considered smooth, hence new divisions are daily required. In the following pages the plan of the former edition will be continued, so far as to form them into three sub-sections, viz., *Naviculeæ*, *Echinellæ* and *Lacernatæ*. In each of these the genera will be placed in alphabetical order, but when a large genus has been divided, its members, or sub-genera, will be found with it. Reference to the index will afford every facility required. (This section is illustrated by P. 2, 3, and 4, f. 127 to 208. P. 13, f. 45 to 50. P. 14 to 20 and 24, except a few figures in plates 14, 15 and 18.)

SUB-SECTION.—NAVICULEÆ (NAVICULACEA *Diatomeæ.*)—Lorica simple, unattached.

Genus ACTINOCYCLUS. (Ehr.)—*The rayed box-like beings;* bivalve, disciform, or shortly cylindrical, cellular *(reticulated);* the cells interrupted by many smooth rays; self-division imperfect, forming chains; lorica with *internal* septa. Kützing, however, characterizes the members of the genus as solitary, and, moreover, as destitute of internal septa.

Ehrenberg observes, that the cellular character of the lorica, distinguishes *Actinocyclus* from *Gallionella*, although an approach to a like condition may be seen in *Gallionella sulcata.*

Actinocyclus, Actinoptychus, and Coscinodiscus, constitute Kützing's family *Coscinodisceæ.* This family is most akin to *Melosira (Gallionella,* Ehr.) but differs by the cellular or reticulated surface of the discs. All the genera are marine.

A very large number of species of *Actinocyclus* have been created by Ehrenberg, the characteristics of which he derived from the number of rays, and where this failed, from the presence or absence of septa. Of the latter plan, the distinction between A. *bioctonarius* and A. *sedenarius* is an example, the number of rays being alike in the two; but the former is destitute of septa, which the latter possesses. More recently, Ehrenberg has created

the genus *Actinoptychus*, to contain all the species of *Actinocychi*, having internal septa: all such, therefore, should be excluded from the present genus. They are continued here on account of their having received their original appellation and position in this genus from Ehrenberg. It is therefore to be remembered, that those species described as having internal septa, are now *Actinoptychi*, with the same specific names.

Actinocyclus *quatuordenarius*, with fourteen rays, and as many internal partitions, sub-dividing its area into distinct cells (loculi.) Diameter 1-480th. Found in the North Sea. Cuxhaven.

Of many remaining forms, it will suffice to indicate the number of radii, and the locality and dimensions.

A. *ternarius*, with three rays. In chalk marl.

A. *quaternarius*, with four septa and rays. Same habit. Virginia. Diameter 1-552th.

A. *quinarius*, with five rays; same habit. Fossil in chalk marl of Ægina, &c.

A. *nonarius.*—Septa absent; rays nine, finely punctated. Found both fossil and alive. The single discs of the fossil forms are generally without margin: they are sometimes quite perfect, but often in broken pieces. In the living creatures, the granules are yellow; locomotion not observable. Diameter 1-720th. to 1-650th.

A. *denarius.*—With ten rays, fossil in the chalk marl of Oran; and living in the waters of the Cattegat.

A. *undenarius.*—Partitions not present, rays eleven, finely punctated. Found alive and fossil. The discs of the fossil forms are destitute of margin, and are single, whilst those of the live creatures have a broad edge and are double. In those specimens in which the margin is absent, there exists as many round openings as there are punctated rays. Diam. 1 560th. to 1-480th.

A. *bisenarius.*—Septa absent, rays twelve, finely punctated. Found fossil and alive with the three preceding. The fossil forms are sometimes smaller than those of the living, but mostly about equal. In the live condition, granules are visible, as twenty-two greenish masses around the colourless spot in the centre of the body. Neither marginal openings nor locomotion have been satisfactorily seen.

Diameter of fossil, as low as 1-860th; of living, as high as 1-580th. This species differs from A. *duodenarius* by the absence of septa.

ACTINOCYCLUS *duodenarius.*—Disc divided internally, by partitions, into twelve cells, and having twelve finely punctated rays; six dark and six bright triangular divisions are seen, in the centre of each of which runs a narrow line, terminating at the margin in a little opening. The internal partitions appear to lie between every two of these narrow lines, so that as many as twenty-four rays may be counted. but there are only twelve openings visible. Diameter 1-560th to 1-480th.

A. *quindenarius.* — Partitions not present; rays fifteen, finely punctated. Fossil and alive in the localities named. The discs of this species are more arched than those of any other of the preceding ones. The fifteen rays terminate in fifteen marginal openings. The granules are distributed into forty-eight round, yellowish, brown-coloured masses, placed around the bright central spot of the body, or else appear united as one ball. Locomotion not perceptible. Diameter of fossil forms, 1-560th; of living, 1-560th to 1-480th.

A. *sedenarius.*—Divided by internal partitions into sixteen cells, and having sixteen finely punctated rays. The granules of a green colour, form, in some, separate concentric masses; in others, a single ball-like mass, placed in the middle of the body. Locomotion not perceptible. Alive near Cuxhaven. Diameter 1-290th.

A. *octodenarius.*—Divided by internal partitions into eighteen cells, and having eighteen finely punctated rays. This species is very similar to the preceding, being only a little larger, and having eighteen septa and marginal openings. The granules in one specimen consisted of seven large yellowish green masses, placed concentrically around the bright central spot of the body, but which did not appear to be strictly confined to the divisions or cells, which, most probably, arises from some optical deception. It was remarkable that, in this specimen, the openings were situated at the margin, in the centre of each division. The play of colour of these divisions depends upon some optical phenomena yet to be developed. In the centre of the disc of those species provided with these divisions, is a broad, bright, and polished umbilicus-like spot, which is invisible in those not pos-

sessing internal partitions. In sea water, along with the preceding. Diameter 1-240th.

Actinocyclus *senarius.*—Discoid, cellular, with six rays and septa. Diameter 1-1150th to 1-720th. Fossil in the Schist of Oran in Greek marl, and alive in the Baltic.

(Group 132, Plate III., represents different views of this species.)

A. *biternarius.*—Like the preceding, but without internal septa. Found fossil in chalk, and alive at Hamburgh.

A. *octonarius.* — Discoid, cellular, with eight rays and septa. Diameter 1-576th. Fossil in the chalk marl of Oran with A. *senarius,* but less common.

A. *septenarius.* — Rays seven, punctate; no septa. Diameter 1-1060th. to 1-430th. Fossil in chalk marl, and alive in the Baltic.

A. *Sol.*—Found by Ehrenberg at the mouth of the Elbe. Characters unknown.

A. *undulatus,* (Kütz.)—Rays six; disc flexuose; cells minute. Fossil at Richmond, Virginia.

A. *tredenarius.*—No septa; thirteen rays. Diameter 1-672nd. Baltic.

A. *biseptenarius.*—No septa; fourteen rays. Diameter 1-720th. Fossil.

A. *quatuordenarius,* with fourteen rays, has also septa.

A. *bioctonarius,* with sixteen rays, but differs from A. *sedenarius,* by wanting septa. Size 1-480th. Island Tjörn, Gothland, and Hamburg.

A. *septemdenarius,* with seventeen rays. 1-468th. Bermuda.

A. *binonarius,* with eighteen rays. Chalk marl of Ægina and the Greek Islands.

A. *vicenarius.*—No septa; twenty rays. Diameter 1-480th. Island Tjörn.

A. *Luna.* — No septa; twenty-one rays. Diameter 1-480th. Same locality.

A. *Ceres.*—No septa; twenty-two rays. Diameter 1-336th.

A. *Juno,* with twenty-three rays.

A. *Jupiter.*—Larger; no septa; twenty-four rays. Diameter 1-432nd. Cuxhaven.

ACTINOCYCLUS *Mercurius.*—Large; no septa; twenty-six rays. Diameter 1-432nd. Island Tjörn.

A. *Pallas*, with twenty-seven rays. Diameter 1-288th. Bermuda.

A. *Saturnus*, with twenty-eight rays. No septa. Diameter 1-432nd. Cuxhaven.

A. *Terra*, with twenty-nine rays. Mouth of the Scheldt.

A. *Venus*, with thirty rays. Diameter 1-216th. Bermuda.

A. *Vesta*, with thirty-one rays. Diameter 1-336th. Bermuda.

A. *Uranus.*—No septa; thirty-two rays. Diameter 1-360th. North Sea.

A. *Achar-nahr*, with thirty-three rays, alive. Hamburg.

A. *Aldebaran*, with thirty-four rays, alive. Hamburg.

A. *Antares.*—No septa; thirty-five rays. (1-288th.) North Sea.

A. *Aquila.*—No septa; thirty-six rays. Alive at Cuxhaven. 1-360th.

A. *Arcturus*, with thirty-seven rays. Alive at Hamburg.

A. *Betegose*, with thirty-eight rays; no septa. (1-360th.) Cuxhaven.

A. *Canopus*, thirty-nine rays. (1-264th.) Bermuda.

A. *Capella*, forty rays; no septa. (1-288th.) Cuxhaven.

A. *Fomel-hot*, forty-one rays. Alive at Hamburg.

A. *Lyra*, forty-two rays. Alive at Hamburg.

A. *Regulus*, forty-four rays. Same locality.

A. *dives.*—No (?) septa; rays fifty-two. (1-360th.) Fossil Greek marl.

A. *Opulentus.*—Rays fifty-five. Found at Antwerp, &c.

A. *Crœsus.*—Rays fifty-five. Alive at Hamburg.

A. *Panhelios.*—Large; no septa; hundred-and-twenty very fine rays. (1-180th.) Mouth Elbe.

A. *velatus.*—Septa and rays six; disc loosely cellular; surface as if overspread by a delicate and finely dotted membrane; resembles A. *biternarius.* (1-372nd.) Virginia.

Genus ACTINOGONIUM, (Ehr.)—Prismatic, not in chains; testules sub-orbicular, with seven, or many (?) angles.

A. *septenarium.*—With seven angles. Found fossil in earth from Barbadoes, along with numerous Polycystineæ.

Genus Actinoptychus, (Ehr.)—Lorica bivalve, in the form of a circular disc, with coincident external rays and internal septa. Surface cellular. Individuals solitary. This genus differs from *Gallionella*, by its individuals being distinct, not concatenated; from *Actinocyclus*, by its lorica having both rays and septa; for *Actinocyclus* is destitute of internal partitions.

This genus, instituted by Ehrenberg since *Actinocyclus*, must embrace many species formerly numbered with the latter,—indeed, all those with internal septa; and there is no doubt, that those having like specific names in the two allied genera, are really identical.

A. *ternarius*.—Disc with three septa. Fossil in chalk marl.

A. *quinarius*.—Disc with five septa. Fossil. Richmond, Virginia.

A. *hexapterus*.—Conical, rays or internal septa six, solid; border of disc thick, sinuose, dentate internally. Can it be a calcareous particle of an *Echinoderm, Coniopelta?* Vera Cruz. Fossil (P. 14, f. 31.)

A. *nonarius*.—Similar, with nine rays or septa. Peru and North America.

A. *denarius*, with ten radiating septa. Richmond, U.S.

A. *vicenarius*, with twenty radiating septa.

A. *Jupiter*, with twenty-four radiating septa. Richmond, Virginia. (P. 14, f. 28.)

Other forms are met with having seven, eight, twelve, and seventeen septa, and might, on the same principles as the foregoing, be considered distinct species.

A. *quaternarius*, has four radiating partitions, and consequently the same number of intermediate cells. Diameter 1-552nd. Fossil in chalk marl.

A. *velatus*, has six rays, and a loosely cellular disc; its surface appearing as if veiled by a delicately spotted membrane. Diameter 1-372nd.

A. *biternarius*, is allied to the preceding species, and has the same number of septa; but its surface is adorned with obliquely dotted lines.

A. *senarius*.—Differs from A. *biternarius* only in the sculpturing of its surface; fossil, Ægina.

Actinoptychus *dives.*—Found fossil at Ægina, with last species.

A. *Ceres.*—Has twenty-two rays. Diameter 1-336th. Virginia.

A. *quatuordenarius*, fourteen septa and rays. Mouth of the Elbe and America.

A. *octonarius*, eight partitions; same habitation; and in polishing powder of Oran.

A. *sedenarius*, sixteen septa. Diameter 1-288th. Cuxhaven and Richmond, Virginia.

A. *octodenarius*, eighteen septa. Diameter 1-240th, Cuxhaven.

A. *duodenarius*, twelve rays and septa. Cuxhaven.

Genus Amphipentas.—Unattached; lorica simple, bivalve, and pentagonal.

This genus is not yet well established, it being open to question whether its supposed species may not be fragments of other organisms.

A. *alternans.*—Pentagonal; sides concave; angles obtuse; the angles of the external pentagon alternating with those of a smaller central one; the latter has also a circular projection at its middle. Cuba. (P. 14, f. 32.)

Is it a calcareous particle of an *Echinoderm?* If *Coniopelta?*

A. *Pentacrinus.* — Pentagonal; its dorsal surface presenting a striated ring. Diameter 1-240th. Fossil in Greek marl. Fragments like *Amphitetras.*

Genus Amphipleura, (Kütz.) — Frustules solitary, navicular, prismatic, longitudinally furrowed; *without* central aperture.

This is one of the genera included in the family *Naviculeæ* by Kützing, but one not well defined.

A. *pellucida.* = *Navicula? pellucida*, (Ehr.)—Slender, elongated, linear lanceolate, not transversely striated, apices obtuse. (P. 16, f. 1.) Length 1-276th. to 1-204th. German Coast and Falaise.

A. *Danica.*—Short, lanceolate, truncate, not striated. (1-390th.) Danish Coast.

A. *rigida.*—Elongate, linear lanceolate, truncate; on one aspect straight; on the other sigmoid. (1-168th. to 1-144th.) Marine. (P. 16, f. 2.)

Genus Amphiprora.—It presents the general characters of *Pinnularia;* but the terminal apertures, instead of occupying the margin, are placed in the median line. Individuals solitary.

A. *constricta.*—Smooth; constricted laterally at the middle. In general form resembles *Navicula alata.* Cuba. (P. 15, f. 1.)

A. *navicularis.* — Oblong, transversely striated; expanded *(dilated)* on the side, at the middle; apices obtuse. Has the habit of a *Pinnularia.* Cuba and United States.

A. *alata,* (Kütz). = *Entomoneis alata,* (Ehr.)—(P. 16, f. 5, 6, 7.)

A. *pulchra,* (Bailey.)—Large, deeply constricted, ends rounded, sides compressed, carinate, distinctly striate, and near the margin punctate. Central portion narrow, sigmoid, with a few fine longitudinal lines. Often contorted, so as to bring one half into a plane at right angles to the other. Long Island, Hudson River, &c.

A. *ornata,* (Bailey.)—"Small, deeply constricted, ends truncated and rounded, sides marked with a longitudinal row of undulations or pinnulæ, as in *Surirella.* Often contorted. The ruffle-like rows of pinnulæ distinguish this species from all others. It probably has minute striæ also, but I did not have an opportunity to examine with high powers."

A. *quadrifasciata,* (Bailey.)—Small, moderately constricted, ends truncate or slightly rounded; sides compressed or carinate, lanceolate, with the apices produced and rostellate. When living, each specimen was marked by four transverse yellow bands. A high power shows the surface to be very minutely striated.

Genus Amphora.—Frustules solitary, with two central apertures, one on each side the median line, but without terminal ones.

The double umbilicus is the distinguishing feature by which it differs from the sub-genera of *Navicula.* It is a member of Kützing's family *Naviculeæ.*

A. *ovalis* = *Navicula* (?) *Amphora.*—Turgid, oval, ends broadly rounded, truncate; margin closely striated; and very fine longitudinal median lines; striæ very fine, nine in 1-1200th; (1-156th to 1-120th.) Fresh water (P. 3, f. 153.)

A. *affinis.*—Oblong, narrowing gently towards the widely truncate ends; margin longitudinally striped, and very fine longitudinal lines traversing the centre. (1-960th to 1-390th.)

AMPHORA *lineolata* = *Navicula lineolata.*—Elliptic-oblong; turgid at the middle; apices somewhat elongated, but truncate; with strong longitudinal lines on the margin, and very fine ones in the centre portion. (1-480th to 1-140th.) Venice, Vera Cruz, Peru.

A. *Veneta.*—Minute; in one aspect, elliptic-oblong; in the other, semi-elliptic; apices truncate. (1-1200th to 1-1080th.) Venice.

A. *elliptica.*—Imbedded in amorphous mucus; lanceolate-elliptic; transversely striated on the margin; apices rather attenuate, but obtuse and truncate, with a central single aperture. Baltic.

A. *aponina.*—Lanceolate-elliptic, extremities produced; truncate, without longitudinal lines. (1-1080th to 1-650th.) In hot springs.

A. *Coffeaformis* = *Navicula* (?) *quadricostata.*—Lanceolate, apices produced, obtusely rounded; with four strong longitudinal lines on the margin, and some very fine ones in the centre. (1-1720th to 1-480th.) In mineral water, Carlsbad.

A. *hyalina.*—Hyaline; elliptic-lanceolate, and more or less acute; traversed by a very few delicate longitudinal lines. (1-600th to 1-432nd.) Baltic.

A. *acutiuscula.* — Lanceolate, ends acuminate, and rather acute; strong longitudinal marginal stripes. (1-576th.) Genoa.

A. *borealis.*—Very small; oblong-lanceolate; in some, ends more acute than in others. Length 1-1200th. In rock streams, Heligoland

A. (?) *Atomus.* — Very minute; on one side elliptic, and ends rounded; on the other, linear and truncate. (1-2640th.)

A. *gracilis.*—Small, oblong, and having a delicate longitudinal band; apices truncate; margin transversely striated. Mexico. (P. 15, f. 26.)

A. *navicularis.*—Small, boat-shaped (navicular); apices acute; lorica transversely striped throughout. (P. 15, f. 37.) This may prove to be a *Cymbella* or a *Cocconema* (Kütz.)

A. (?) *carinata.*—Large, navicular; plane on each side, extremities acute; striæ in four lateral fasciæ. (1-240th.) Island of Tjorn.

A. *crystallina.* — Smooth, convex dorsally; concave ventrally; broadly truncate at each end. (1-432nd.) Tjorn.

A. *fasciata.*—Dorsum convex in the middle; venter plane; with closely set and slender longitudinal rows of striæ, about twelve in number; ends widely truncate. (1-456th.)

AMPHORA *Lybica.*—Dorsum convex its entire length; venter concave; sides punctate; striate on their inner margin. (1-288th.) Found in the Oasis of Siva, Mexico, United States, &c. (P. 15, f. 38.)

A. *rimosa.*—Discovered and named by Ehrenberg, among other American *Bacillaria.*

A. *Fischeri.*—Turgid at the middle, ends widely truncate; three longitudinal marginal lines; central lines obsolete. (1-576th.) Carlsbad. Probably a variety only of A. *Coffeaformis.*

A. *Amphioxys* (Bailey.)—Ventral side rectangular, with slightly rounded ends, and two arcuate bands of striæ, which are broadest near the centre; back convex, minutely striate; sides convex above, minutely striate; concave below, strongly striate; ends produced and rostellate. The side view of this species bears a striking resemblance to *Eunotia amphioxys* (Ehr.)

Genus ANAULUS.—Lorica simple, bivalve, compressed, subquadrate; spontaneous fission complete, hence no concatenation. This genus approaches *Biddulphia* by the constrictions on its sides, but is without tubular processes, and lateral apertures.

A. *scalaris.*—Smooth, turgid in the young state; but when full grown, very wide and much flattened, with four, six, eight, fourteen lateral constrictions, which give it, when viewed on the side, a ladder-like (scalariform) appearance. Diameter 1-480th to 1-180th. Antarctic Ocean.

A. *campylodiscus.*—Quadrangular; each valve very much compressed, triangular, with obtuse angles; with two slight constrictions laterally. It has the habit of an unequal-sided *Triceratium*, or of a *Campylodiscus.* Diameter 1-372nd. Bermuda.

Genus ARACHNOIDISCUS (Deane.)—Lorica circular, discoid, bivalve, divided into cells (loculi) by incomplete septa; centre of disc clear, occupied by a foramen, surrounded by denticles, equal in number to the rays, and with an external contiguous circle of puncta (foramina.) Interspaces between the rays occupied by fine concentric or transverse lines; also, at the periphery, by short projecting septa.

The disc, in its markings, has been compared to a spider's web—hence the name. Its affinity is with *Actinoptychus.* Mr. Shadbolt has intimately examined the structure of the shell. He says—"It

is not strictly bivalve, although capable of being separated into two corresponding portions; but is more properly multivalve, as consisting of two discoid portions, and of two annular valves, exactly similar respectively to one another. Each discoid valve is further separable into an outer, very thin, somewhat flexible, and elastic membrane, on which are the characteristic spider's web-like markings. (P. 24, f. 18); and a siliceous frame-work, resembling a circular gothic window. (P. 24, f. 19.) . . . It is indisputably evident, that a central opening is present, partially covered *internally* by a delicate cup-like process (membrane), so as to form a species of valve. The two annular valves are situated between the two discoid ones; and thus the whole shell, in its natural state, resembles a circular snuff box. These valves consist of a siliceous ring, within which, (extending a slight distance towards the centre) is an annular membrane, and when *in situ*, the valves are placed so that the membranes of each valve are in contact; and thus the space included between the two discoid valves is partially divided into two (not three) chambers." (Trans. Mic. Soc. V. 3, p. 49.) Mr. Deane has supposed the presence of a short siliceous pedicle; but Mr. Shadbolt is satisfied there is none, but that all the shells are sessile. The latter thinks it probable, they *may* propagate by self-division; yet they occur of all imaginable diameters, from 4-1000th to 14-1000th of an inch, and the number of rays, in each individual, is by no means constant.

It should be added, that this same observer is disposed to consider them animals, and that he supposes food to be taken in through the openings about the centre, not improbably by tentacula, arranged like those of *Madrepores*. (P. 24, figs. 18 to 21.)

Arachnoidiscus *Japonicus.* — Specific characters unknown. So named, because found on Algæ, from Japan; used as an article of food.

Mr. Shadbolt intimates the existence of other species, found in Ichaboe guano; Algæ from the Cape of Good Hope; from North America, &c.

Genus Asterodiscus (S. Johnson.)—Lorica simple, bivalve, siliceous, circular; from the side bi-convex, not forming chains. Umbilicus smooth, nearly circular; divided from the margin by imperfect septa, of which every two unite half way to centre; the rest radiating

between the septa, umbilicus produced to margin by radii, which are smooth and flat—the one preceding between the two united septa, smaller than the other. Spaces between radii elegantly marked by dots, arranged in eccentric curves. It differs from *Asterolampra*, where all the divisions are symmetrical; from *Asteromphalus*, the two umbilical septa are nearly parallel, and the corresponding marginal radius is wanting. Three species were found by A. S. Johnson, Esq., in Piscataway and Richmond, (N. A.) earths; fossil guano from the Chincha Islands off the coast of Peru; and in the Bermuda earth, along with specimens of *Asterolampra Septenaria*, and *Eupodiscus? Tripes*, (Silliman's American Journal, 1852.)

A. *quinarius.*—Five marginal radii and umbilical divisions.

A. *senarius*, with six radii and divisions.

A. *nonarius*, with nine radii and divisions.

Genus Asterolampra, (Ehr.)—This genus is intermediate between *Actinocyclus* and *Actinoptychus*. Lorica simple, symmetrical, bivalve, and circular; divided by imperfect internal partitions (dissepiments,) alternating with the perfect radii visible on the surface. Form very elegant; but fission being complete, it does not occur in chains.

A. *Marylandica.*—Rays eight, reaching the margin; and as many alternating partitions, radiating also from the centre, but incomplete, Curved rows of puncta occupy the interspaces. Diameter 1-192nd. (P. 14, f. 33.)

Genus Asteromphalus, (Ehr.)—Lorica simple, symmetrical, bivalve, and orbicular. Fission complete; hence individuals not found in chains. Each disc marked by alternating rays, giving the appearance of a double star. Umbilical rays (imperfect partitions, *septa*) not attaining the margin, two parallel, the rest divergent. Marginal rays smooth, plane, and one of them, in all species and individuals, wanting, or so obselete, that two umbilical, one on either side of it, become parallel,

The fossil American genus *Asterolampra*, approaches nearest to *Asteromphalus*, but differs from this by all its rays being perfect, and by their alternation and divergence being also perfect and symmetrical.

A. *Darwinii.*—Umbilical rays, five; flexuose, with four marginal rays, the fifth obsolete. Diameter 1-960th. Antarctic Ocean.

Genus ASTEROMPHALUS, (Ehr.) *Hookerii.* — Six umbilical rays, straight; five marginal rays, the sixth obsolete. (1-420th.) Antarctic Ocean.

A. *Rossii.*—Six inflected umbilical rays; five marginal, the sixth obsolete. (1-504th.)

A. *Buchii.* — Seven straight umbilical rays; six marginal, the seventh obsolete. (1-504th.)

A. *Beaumontii.*—Seven inflected umbilical rays; six marginal, the seventh obsolete. Diameter 1-648th.

A. *Humboldtii.*—Eight straight umbilical, and seven marginal rays, the eighth marginal obsolete. Diameter 1-372nd. (P. 14, f. 34.)

A. *Cuvierii.*—Nine umbilical straight rays, and eight marginal, the ninth marginal wanting. Diameter 1-392nd. Antarctic Sea.

Genus AULACODISCUS.— Lorica composed of two equal valves, orbicular and unilocular (one celled), with apertures on each valve near the margin; very shortly tubular, and severally continued to the centre by a distinct furrow (sulcus.)

Aulacodisci are *Eupodisci*, furnished, in the place of pediform tubules, with bands radiating from the centre, and becoming connected with the tubercles seated just within the margin, and having the surface of their valves granular and not cellular.

A. *crux.*—Testules rather convex; margin finely radiated, forming a rim around the cellular, granular disc; twelve pearl-like granules in 1-1200th, and some rows of granules radiating from the centre, with four series representing a crucial suture, stronger near the margin. Diameter 1-384th. Richmond, Virginia.

Genus AULISCUS.—Lorica bivalve, cylindrical (or orbicular) multiplying by perfect self-division; two large (not tubular) apertures on each surface of the disc laterally, which also is not cirrhose.

This genus differs from *Cerataulus*, in wanting the cirrhose surface of the lateral discs, as also the tubular apertures.

A. *cylindricus.*—Cylindrical, with a plane orbicular disc on each side, having a rim, and a central area figured by various radiating lines; with two opposite apertures, opening obliquely on the margin. (1-576th to 1-288th,)

A. (?) *gigas.*—Margin of the sides tumid and perforated, sculp-

tured by elegant rows of dotted, imperfectly radiant lines. (1-348th.) Ægina.

Auliscus *polystima* = *Coscinodiscus polystigma*, of the Frisian Sea.

Genus Bacillaria, (Ehr.)—Lorica bivalve, or multivalve, in the form of a many-sided prism. Self-division complete; but the frustules do not entirely separate at their angles, and thus they form gaping or zig-zag chains (figs. 166 to 170); even when thus connected together they are motile. "The organs of locomotion," says Ehrenberg, "are soft peg-like processes, projecting from a longitudinal cleft; in *B. tabellaris*, transparent polygastric vesicles have been seen. Two openings are visible at the end of the lorica; hitherto the nutritive organs have not been demonstrated by artificial means. At one time it was supposed these animalcules had no mouth, but were nourished by absorption. Self-division always longitudinal and dorsal, so that the surfaces which hang together are those of the sides. A small deflection and locomotion of the chains is observable in the fresh water species, but is more remarkable in the marine varieties of *B. paradoxa*, which, when separated, move quickly, like *Navicula*. The name *Bacillaria* was first given to them by G. Malin; botanists gave them the names of *Diatoma*, *Conferva*, and *Oscillatoria*. They form part of the genus *Vibrio* of Müller." Nägeli states, the individuals of this genus possess a nucleus. See genus *Diatorma* (Kütz.)

B. *paradoxa* *Vibrio paxillifer* (M.)—Lorica straight, slender, striated; often fifteen times longer than broad. Nine striæ occur in 1-1200th. It is of a yellow ochre colour, and its locomotion is distinct. In consequence of incomplete self-division, the frustules adhere side by side, and the band-like clusters thus formed are either straight, wavy, or zig-zag, according as they slide one upon another. The individuals forming the chain, can detach themselves, and then move freely about like *Navicula*. Group 167 is a polype-like cluster, and fig. 166 a front and side view of a single specimen. Found upon sea-weed. Length 1-1150th to 1-240th.

B. *vulgaris* = *Diatoma vulgare* (Kütz.)—Straight; three or four times longer than broad. It has thirteen transverse striæ in 1-1200th. Fig. 168 is the dorsal view of part of a group of four specimens; viewed sideways, they resemble a spindle. Found fossil and alive, both in fresh and salt water. In the Rhone, it covers over *conferva glomerata*, in the form of a thick felt.

Kützing says: "The connected band of frustules (loricæ) is attached by an elongated, but inconspicuous stalk." Length 1-570th to 1-430th.

Bacillaria *pectinalis* = *Diatoma tenue* (Ag.) — Slender, striated; often three to six times longer than broad; of a brownish yellow colour; striæ nine in 1-1200th. Kützing affirms that the chain is affixed by an indistinct stalk. Length 1-3240th to 1-430th. In fresh and salt water.

B. *elongata* = *Diatoma Ehrenbergii* (Kütz.) — Striated, slender, slightly contracted in the middle (P. 3, f. 169.) Striæ twelve in 1-1200th. Chain fixed by a very minute stalk (Kütz.) Length 1-1150th to 1-240th. In ponds, common.

B. *cuneata.*—Wedge-shaped (*cuneate*), striated (fig. 170), margin with a few teeth; length not double the width; lateral view ventricose, lanceolate. It approaches near *Odontidium mesodon* (Kütz.) Length 1-1150th to 1-1200th. Fresh water.

B. *Cleopatræ* = *Grammatophora marina* (Kütz.)—Oblong, destitute of striæ; colour golden yellow. Was found by Ehrenberg near the ruins of the Baths of Cleopatra, in Egypt. Length 1-570th to 1-480th.

B. (?) *tabellaris* = *Tabellaria flocculosa* (Kütz.)—Smooth, narrow, slightly enlarged at the middle; frustules occuring in the form of square plates; granular contents yellowish. Length 1-1150th to 1-960th. In fresh water on Conferva.

B. *flocculosa.*—Smooth, almost square, not enlarged at the middle. In ponds and streams. Length 1-1440th.

This, and the two following species, Kützing considers to be represented by his *Diatoma pectinale.* The lateral view he describes to be sharply lanceolate.

B. *seriata.*—Slender, straight, eight to nine times longer than broad; smooth; the contained granules occur in four to five masses. Length 1-360th. In slow streams and ponds on Conferva.

B. *Ptolomæi.*—Smooth, very small, length twice or thrice the breadth. Colour pale. Found in Alexandria. Length 1-3600th.

As a member of this genus, Nägeli describes the following organism:—

Each cell or segment has the form of a column, the bases of which are ellipses. The axis is rather shorter than the long

diameter of the bases; hence the cell appears almost square (P. 24, f. 28) on the broad side, on the narrow side a longish rectangle. On the bases are four ribs, parallel with the broad diameter of the ellipse The bases also present many slight indentations. The ribs are merely in the membrane, as may be ascertained by a side view. They extended, however, a short distance on both sides, over the lateral surface of the cylinder, and are gradually lost. The nature of the ribs is not to be made out in these plants, from analogy to the above-described (see genus *Gallionella nov. sp.*) It becomes probable that they are formed by secreted extra cellular substance. See description of Plate 24, figs. 26, 27, and 28.

The cell-contents consists of a colourless transparent fluid, and a free nucleus-like heap of chlorophyl, mingled with mucilage In propagation, this green mass divides into two parts, between which the septa appears.

Among the *Bacillaria* figured by Ehrenberg, it exhibits the greatest affinity to B. *cuneata*, and is almost of the same size, viz.— 1-1152nd to 1-1200th. The latter, however, is distinguished.—1. By the alternating broader lateral borders. 2. By the individual cells remaining attached together at one angle after division. 3. By the striæ not being straight upon the dividing wall, and not parallel with the axis, but running at an oblique angle over the broad lateral surface; and 4. By the additional existence, on both sides, of two striæ on the lateral margin (on the narrow lateral surface.)

Unlike the ordinary members of the genus *Bacillaria*, the individuals of the species in question only remain united together immediately after the division of the parent cell, subsequently they are completely separated, or, in other words, are free. (Ray Society, 1844, p. 267.)

Some of the preceding species of *Bacillaria* will be found again referred to, with additional matter, under the genus *Diatoma*.

Genus Biblarium.—Lorica tabular, made up of many lamina; transverse in relation to the length; central portion smooth, but the lateral segments, like the covers of a book, ornamented with transverse striæ. The smooth central portion of each individual, is furnished with a large umbilicus at its middle. There are quadrangular, elliptical, and cylindrical varieties in this genus.

Biblarium is intermediate between *Tessella* and *Tabellaria;* it approaches *Striatella,* but differs from that genus by the absence of a pedicle.

All the species hitherto met with are fossil. Ehrenberg supposes them, from their geological position and relations, to have been inhabitants of brackish water.

The above characters are gathered from a report on a paper by Ehrenberg, read before the Berlin Academy.

BIBLARIUM *Glans* = *Navicula* (?) *Glans.*—Laterally valves oblong, tumid at the centre, apices obtuse; with loose parallel striæ, seven to eight in 1-720th, or four to six in 1-1440th. No suture visible. Length 1-480th. Finland, Siberia, and Oregon.

B. (?) *gibbum.*—Smooth, bacillar; two, three, or four concatenated; straight at the centre; laterally, gibbous at the centre. No central aperture observable. Length 1-1152nd. Kurdistan.

B. *compressum.*—Laterally narrowly elliptic; lanceolate, obtuse, with loose, transverse, parallel pinnæ, interrupted by no median suture, and five to seven in 1-1152nd. Length 1-648th. Oregon.

B. *castellum.*—Ovate, obtuse; with four marginal sinuses on each side. Lateral valves not observed. Length 1-900th. Siberia.

B. (?) *Crux* = *Navicula crux.* — Lateral valves quadrangular, striated; deeply and unequally angular, so as to resemble the figure of a cross; with transverse parallel striæ, interrupted by a median suture; eighteen in 1-1152nd. Length 1440th to 1-864th. Fossil, Hesse Cassel; living and fossil in Siberia.

B. *ellipticum.*—Lateral valves elliptical, striated transversely; without a suture. Striæ five to eight in 1-1152nd. Length 1-1080th. Siberia and Oregon.

B. *emarginatum.* — Lateral valves quadrangular, unequally and deeply angular, assuming a crucial form, with two opposite (ventral) obtuse and emarginate rays; transverse striæ strong, but lax, seven in 1-1152nd. No suture. Length 1-864th. Siberia and Mexico. "I have seen nineteen leaflets concatenated, and two such collections (libelli) also connected" (Kütz.)

B. (?) *Follis,* of North America = *Navicula* (?) *Follis* of Europe; but would perhaps be more rightly transferred to *Tabellaria.*—Lorica depressed, swelled at the middle, without longitudinal striæ. It i

deficient of the margin *(rima)* and suture of *Navicula*, and the central aperture appears too small. Length 1-2300th. Massachusetts.

Biblarium *Lamina*.—Lateral valves widely linear, rounded at the ends, slightly constricted in the middle; suture absent; pinnules seven to eight in 1-1152nd. Oregon.

B. *Lancea*.—Lateral valves lanceolate; apices subacute; pinnules parallel, three to eight in 1-1152nd. Suture wanting. Length 1-336th. Oregon. Ehrenberg has met with twenty-seven valves concatenated.

B. *lineare*.—Lateral valves narrowly linear, rounded at the ends or subacute; not contracted at the middle; striæ lax, strong, four to eight in 1-1152nd. No suture. Length 1-552nd. Siberia and Oregon.

B. *Rhombus*.—Lateral valves ovate, rhomboid, quadrate; apices subacute; median angles more obtuse; striæ lax, six to eight in 1-1152nd. No suture. Length 1-864th. Siberia and Oregon. Some examples are met with having more acute median angles.

B. *speciosum*.—Lateral valves elongate, turgid at the centre and at each end; broader on the ventral surface; one extremity frequently subacute, the other more obtuse; pinnules strong, but lax; suture obsolete, not altogether absent. Striæ four to eight in 1-1152nd. Length 1-336th. Oregon.

B. *Stella*.—Lateral valves quadrangular, unequally sinuated, hence a crucial outline; striated; ends obtuse; striæ parallel, lax; suture absent. Length 1-696th. Oregon, Siberia.

Genus Campylodiscus.—Valves equidistant, (not concave); individuals (frustules) solitary, or temporarily, during self-division, in pairs; disciform; tortuous or saddle-shaped; elliptic, sub-orbicular; striated, striæ mostly radiate.

Further views of this genus are enunciated in the description of C. *Horologium*.

Campylodiscus is a member of the family *Surirelleæ*, of Kützing; it approaches *Melosira* (*Gallionella*, Ehr.), but differs in having an elliptic instead of a circular disc.

"The species, (says the Rev. W. Smith) included under this genus, may all be recognized by the characteristic bend or contortion of their surfaces, which gives to the frustule, under certain aspects, the semblance of a miniature saddle. Kützing has indeed removed from

Campylodiscus, and placed in *Surirella*, several species possessing this character, apparently for no other reasons than that the striæ or costæ are confined to the margins of the valves, and are parallel, not radiate. When we consider that the striæ are often exceedingly difficult of detection, and that their direction, merely, cannot be regarded as necessarily implying an important difference in internal structure, the circumstances alluded to do not seem a sufficient ground of exclusion, and it would perhaps be as well to allow *Campylodiscus* to include all those species with equidistant valves, to which its very significant name can with propriety be applied." (Ann. Nat. Hist. v. 7, 1851.)

CAMPYLODISCUS *radiosus.*—Small; its centre smooth, and sending off about seventy closely set and broad rays. Fossil. Vera Cruz, Mexico.

C. (?) *striatus.*—Centre smooth as in preceding, with two series of thirteen parallel transverse striæ on each side of a clear interval. Fossil. Vera Cruz, Mexico.

C. *Clypeus.* = *Cocconeis clypeus.*—Sub-orbicular; with the rays interrupted (broken) by a smooth band; punctato-reticulate at centre of disc. Diameter 1-576th. to 1-216th. Fossil in Franzensbad Bohemia. Original drawings of this elegant fossil are given in P. 12. f. 516, 518.

C. *noricus.*—Sub-orbicular, with continuose (unbroken) rays, seven in 1-1152nd.; smooth at the centre. Diameter 1-432nd. Alive at Salzberg. Fossil at San Fiore.

C. *Remora.*—Sub-orbicular; rays interrupted; centre of disc smooth. Diameter 1-480th. Alive at Wismar, on the Baltic.

C. *Echeneis.*—Sub-orbicular, porous; having continuous rows of pores extending from the smooth, *solid*, central area. Diameter 1-288th. Wismar, Baltic. Alive.

C. *vulcanicus.*—Large, sub-orbicular; centre smooth; margin wide, with about forty-two rays. Diameter 1-480th. Peru.

C. *hibernicus.* — Testules large, sub-orbicular, with continuous (unbroken), loosely disposed rays, four in 1-1152nd. Rays rough; centre smooth. Ireland.

The following species have been recently described by the Rev. W. Smith.

C. *costatus.*—Valves orbicular; costæ distinct, radiate, about forty-

four; centre of disc smooth or minutely punctate. Average diameter 1-230th. A fresh water species, living and fossil in Great Britain and Ireland.

It approaches C. *radiosus*, (Ehr.); but its cortæ are more numerous and longer.

It may possibly be identical with C. *noricus*, (Ehr.)

Campylodiscus *spiralis*. = *Surirella spiralis*, (Kütz.) — Valves elliptical; frustules twisted so as to present a spiral outline; costæ distinct, about sixty, parallel or slightly radiate; centre smooth or minutely punctate. Average length 1-170th; breadth 1-400th. In fresh water, Guildford, Surrey.

C. *cribrosus*.—Valves orbicular; disc marked with radiating lines of minute perforations, crowded towards the margin. Diameter 1-240th. This probably = C. *Echeneis*, (Ehr.), but the description of the central area in that species as solid, *i. e.* unperforated, will not apply to the present; the perforations extending over the entire surface, though more distant, and somewhat scattered in the middle.

C. *parvulus*, (Smith.)—Valves orbicular; disc traversed by two parallel ridges; striæ about twelve, nearly parallel. Average diameter 1-550th. Poole Bay, 1848. This species is readily distinguished by its minute size, and the ridges on its valves, which are very prominent in certain portions of the frustule. It does not appear to have been noticed, either by K tzing or Ehrenberg. (P. 24. f. 22, 23.)

C. *Horologium*. — Disc orbicular, slightly saddle-shaped; centre smooth; margin radiated. Mr. Williamson, who describes this as a new species, dredged off the coast of Skye, states, the disc to be less curved than the Bohemian *C. clypeus*, and still less so than the *C. zonalis* of Mr. J. Phillips. Around the smooth disc is a circle of short elegant projecting radii, which extend nearly to the periphery, and give to the whole the general aspect of the face of a clock or watch, the radii representing the figures marking the hours. Within this ring, and closely bordering the inner extremities of the rays, is a circle of very minute and slightly elongated tubercles, like those which surround the central *siliceous* umbo of the *Arachnoidiscus Japonicus*, but much smaller. There are usually four or five of these to each interspace, separating the rays. A

smaller circle, but with the tubercles rather more conspicuous and elongated, connects the outer extremities of the rays with the extreme margin of the disc. On the more elevated portions of the inflected disc, the rays appear to be rather stronger than elsewhere. Diameter 1-145th.

"My specimens consist of at least three layers, inclosing two inner cavities, which contain a green endochrome. In this it resembles many other allied forms. From what has appeared a single disc of *Arachnoidiscus Japonicus,* I have separated as many as six siliceous layers.

"This separation into lamina, marking the existence of so many distinct frustules, reminds us of *Melosira* and its allies; a resemblance that becomes the more striking, when we consider, that, as in *Melosira,* the first frustules of *Arachnoidiscus, Cocconeis,* and many others, are attached as parasites to some other body. In the analytical table of the *Bacillaria,* page 221, Ehrenberg includes many of these objects; classing *Cocconeis, Actinocyclus,* and what he calls *Bacillaria,* together in his group of *Naviculæ,* and characterizing them as free, in contra-distinction to his fixed forms, in which latter he includes *Isthmia* and other genera. It appears evident, however, that *Cocconeis* and *Arachnoidiscus* are as 'fixed' when found *in situ* as any of the *Diatomaceæ;* and probably many of these other allied genera will eventually be found to exhibit the same features when better known."

Campylodiscus *Argus* (Bailey.)—Large, circular, and saddle-shaped, surface marked with rows of conspicuous dots; margin smooth, with a row of pinnulæ, placed at a short distance from its edge. A fine, large, and very distinct species, which appears to be widely diffused in the estuaries of the United States.

Genus Cerataulus, (Ehr.)—Lorica bivalve, sub-cylindrical, or sub-orbicular; multiplied by perfect spontaneous fission; hence not concatenate; with two tubular apertures, and as many cirrhi, alternate with them, on each surface of the lateral disc.

This genus and *Auliscus* connect *Zygoceros* with *Campylodiscus,* and differ in the same manner as do *Biddulphia* and *Denticella* which present concatenated, or imperfectly separated forms. *Cerataulus* = non-concatenate *Denticella.*

CERATAULUS *turgidus.*—Pores aggregated in a band on the margin of each valve of the testules. In form it is always tortuous. Diameter 1-432nd. Found in the Baltic Sea.

Dr. Bailey describes this species as follows :—"Frustules globular, or slightly compressed, with two large rounded prominences at each end, cohering by alternate angles, forming zigzag chains. Between the two rounded processes, and in a plane at right angles to that containing them, are placed two long horn-like processes. Two frustules are often connected by an external decussately punctate cell, as in *Isthmia* and *Biddulphia.*"

Genus CERATONEIS.—Individuals solitary ; lorica prismatic, quadrangular, bivalve, and rostrate, with a central umbilicus, from which two longitudinal furrows may be traced into the prolonged horns (beaks.) Self-division complete ; hence individuals not chained, though sometimes found in pairs.

The general figure of *Ceratoneis* is that of *Navicula*, but with the apices much produced. In Kützing's arrangement it is a member of the family *Naviculeæ.*

C. *Closterium.*—Setaceous and lunate in figure ; central portions linear lanceolate ; horns very long, twice the length of the body ; granular contents brownish green, occupying only the central part, the horns being colourless ; lorica smooth ; in form it resembles *Closterium setaceum ;* movements active and gliding. Abundant in the sea at Cuxhaven, &c. Length 1-290th. to 1-144th. Body without horns, 1-1150th. (P. 15, f. 59.)

C. *fasciola.*—Linear lanceolate ; horns shorter than the body, but curved in opposite directions, so that the lorica resembles the letter S. The body without the horns is like *Navicula gracilis.* Locomotion distinct. Length 1-430th. Cuxhaven. (P. 15, f. 60, 61.)

C. *Cretæ.*—Navicular, smooth, rather constricted and flattened in the middle ; apices acute, straight, not much produced. (1-576th.) Chalk marl, Sicily.

C. *laminaris.*—Broadly lanceolate, transversely striated on the margin ; beak short. Mexico.

C. *arcus.* = *Navicula arcus.* — Narrow, linear, curved, smooth ; dorsum convex, rather dilated in the centre of the ventral surface ;

apices elongated, tapering, recurved. Length 1-570th. Fresh water. (P. 3, f. 147.)

Ceratoneis *spiralis*, (Kütz.)—Narrowly lanceolate, the flat beaks spirally twisted, and somewhat obtuse at the ends. Length 1-240th. On the sea coast. (P. 16, f. 9.)

Genus Chætoceros.—Concatenated; lorica of two equal turgid valves, with two apertures on each side, which, at the earliest period, are very shortly tubular when the corpuscles are contiguous, but are afterwards produced as long cornua when the corpuscles become remote. The cornua become transformed ultimately into very long, slender, and siliceous entangled threads.

These singular forms have a distant resemblance to *Denticella;* and individual corpuscles have the habit of *Peridinia*. The filament-like cornua, detached, may be mistaken for *Gallionellæ*.

C. *dichæta*.—Each testule smooth; the two horns of each side often flexuose, and in course of time very long and filiform. Diameter of each corpuscle, with the cornua, 1-1152nd. to 1-720th. Antarctic Sea.

C. *tetrachæta*.—Smooth; horns four on each side, becoming very long, and filiform. Diameter 1-1152nd.

C. (?) *Bacillaria*.—Bacillar; breadth three to four times greater than depth; truncate at each end, and furnished with two long filiform cornua. Diameter 1-864th. Bermuda.

C. (?) *Diploneis*.—Constricted at the middle, rounded at each end, with the habit of *Diploneis*, but with two filiform cornua from each end. Diameter 1-960th. Bermuda.

The two preceding forms were first observed and figured by Dr. Bailey.

C. *didymus*.—Smooth, width double its heighth, with two semi-orbicular angular valves, almost of the character of *Euastrum*, with two decussating filiform cornua from the middle of each side. Largest diameter 1-1080th. Fossil in African Guano. *Goniothecium Gastridium* found along with the preceding, may belong to the same genus, but having, in its fossil state, its cornua broken off.

Genus Cocconeis.—*The shield-like Navicula*. Lorica bivalve, prismatic, or somewhat hemispherical, with two apertures, one in the

middle of each piece, but without terminal pores. Never developed in the form of a chain or cluster; propagation by self-division, or gemmules, is doubtful; mostly striated; the transverse striæ appear to be internal flutings like ribs. The lorica is composed of two lateral pieces, joined together at a central furrow, somewhat resembling the keel of a boat, the under surface being flat, the upper somewhat arched. A foot-like process has been seen projecting out of the central opening, on the under surface. The internal matter is green or yellow, and often appears to be formed in two plate-like masses. Though actual motion has not been observed, change of place appears to ensue.

Kützing makes *Cocconeis* the type of a family *Cocconeidæ,* order *Stomaticæ,* (see page 308.) In defining the genus *Cocconeis* he is at variance with Ehrenberg, in stating that its members are ultimately adnate (attached) and sessile.

Cocconeis bears the greatest resemblance to *Eunotia* (Ehr.) and *Epithemia,* (Kütz.) but is at once distinguished from them by having a central aperture, whilst it wants terminal openings. The central umbilicus is found only on one surface; the idea of Ehrenberg, that a foot-like process can be protruded from this spot, is unconfirmed; indeed, it is pretty well ascertained, that the supposed openings are not actually such, but either depressions or elevations, more probably the former, of the surface of the lorica.

The development of *Cocconeis* by self-fission, considered doubtful by Ehrenberg, is spoken of as unquestionable by Kützing, who also describes the very small specimens as occurring together in great number, and enveloped in a gelatinous substance. Moreover, little doubt remains, from the researches of Mr. Thwaites and others, that *Cocconeis,* like its allied genera *Cocconema* and *Eunotia,* is propagated by the process of conjugation. The members of this genus are met with abundantly, both in fresh and salt water, floating about in an isolated manner, or more commonly still, parasitic on Algæ, such as *Cladophora, Callithamnium, = Polysiphonia,* Conferva, &c. They occur also in the fossil state. The marine species are most beautifully sculptured, whilst the fresh water are smooth.

Cocconeis *scutellum.*—Elliptic, convex on one surface, with trans-

verse, finely punctate, and curved striæ; common on sea-weed,—as Ceramium. Fossil at Cassel, North America, &c. Length 1-1150th. to 1-240th. (fig. 162, 163.)

Cocconeis *undulata.*—Similar to the preceding, except in being sculptured with very delicate, concentric, undulating lines, instead of transverse striæ. Length 1-432nd. On sea-weed, Baltic.

C. *placentula.*—Plane, elliptic, smooth, with an abrupt margin. Length 1-1440th. In fresh water, upon Vaucheria and Lemna.

C. *pediculus.*—Small, elliptic or oval, convex and smooth; the disc presenting a very fine longitudinal line, and the margin three lines. Length 1-2200th. to 1-960th. Common on fresh water Algæ.

C. (?) *Finnica.*—Ovate, oblong, slightly convex; smooth externally, but striated within. Length 1-570th. Fossil; Finland, Mexico, &c.

Var. (*b.*)—Larger, very elliptic, elongate, three to four times longer than broad. Length 1-360th. Alive at the mouth of the Elbe, and Antwerp. (P. 15, f. 41.)

C. *Americana.*—Smooth, with the habit of C. *Mexicana*, but striæ obsolete. Mexico.

C. *borealis.*—Smaller, much elongated and elliptic, transversely striated. = C. *Islandica* of Mexico. Iceland.

C. *concentrica.*—Small, broadly elliptic, ends widely rounded, and with four concentric longitudinal lines on each side. Mexico.

C. *decussata.*—Larger, broadly elliptic; rough, decussated by rows of puncta, *(apiculi?)* Cuba.

C. *elongata.*—Smaller, smooth, ovate-elliptic, plane. Approaches C. *Placentula*, but is smaller; it, however, may be but a variety. Massachusetts.

C. *fasciata.*—Elliptic, larger, linear, with two longitudinal lines, and a smooth transverse band at its middle. Peru.

C. *Leptoceros.* = *Rhaphoneis Leptoceros.*—Still larger; has the habit of C. *Amphiceros*, but its beaks much longer.

C. *longa.*—Small, smooth, linear, rounded on each side. Iceland.

C. *Mexicana.*—Rhomboid, punctato-striate, small; ends obtuse, and rather prolonged. It is small and more obtuse than C. *Rhombus*. Mexico. (P. 15, f. 48, *a. b.*)

COCCONEIS *prætexta.*—Small, elliptic, with six longitudinal lines on each side of the centre; and a dilated, smooth, areolar margin.

C. *punctata.*—Very small, elliptic, with eight longitudinal lines each side of the median line. Mexico.

C. (?) *Crux.*—Smooth, elliptic, slender, with a transverse linear umbilicus. Diameter 1-1632nd Bermuda..

C. *rhombea.*—Of the form of a rhombus, with generally three longitudinal lines each side the centre. Length 1-1200th. Alive at Niagara. It is very like C. *Mexicana* and C. *Americana.*

C. *Amphiceros*—Roughly striated; navicular on the side; each extremity suddenly attenuate and much prolonged (rostrate), narrowly linear on the back. Length 1-576th. Marine at the mouth of the Elbe. See *Rhaphoneis Amphiceros.*

C. *limbata.*—Sub-orbicular, elliptic, with a porous wide margin? disc with twelve longitudinal fine lines passing along its middle; ends widely rounded. Length 1-576th. Salzberg.

C. (?) *Navicula.*—Striated; navicular on the sides; narrowly linear on the back, with an indistinct central longitudinal sulcus (furrow.) Length 1-864th. Marine. The Elbe; parasitic on *Bacillaria paradoxa.*

C. *Rhombus* = *Rhaphoneis Rhombus.*

C. (?) *margaritifera.*—Broadly ovate; each end subacute, with transverse granular striæ, like rows of pearls. It is closely allied to C. *Mexicana,* but rather larger and not curved. Bosphorus.

C. *scutum.*—Found by Ehrenberg, in earth from New Holland.

C. *disciformis.*—From the same locality.

C. *navicularis.*—From the same locality.

C. *gemmata.*—Found in the chalk marl of Ægina.

C. *oceanica* (Ehr.)—Elliptic, suborbicular, convex, marked by simple curved and concentric lines; not undulated; transverse striæ none. Length 1-1150th. In sea water, Callao, Peru. (P. 15. f. 42.) Kützing describes this species as rounded, with numerous very delicately punctate longitudinal lines. Length 1-624th. Baltic, North Sea, Peru, &c. He considers it identical with Ehrenberg's species; but it has curved and concentric lines.

C. *pygmæa* (Kütz.)—Minute, elliptic, very smooth, surrounded by

a crenulate border. Baltic and North Sea, on Ceramieæ. Length 1-2640th.

COCCONEIS *molesta* (Kütz.)—Minute, elliptic-oblong, very closely aggregated, quite smooth, without a border (limbus.) On Callithamnion, Venice. Length 1-1800th to 1-1680th.

C. *salina.*—Narrower than C. *Pediculus,* punctated, and very delicately transversely striped near the margin. Probably is but a variety of C. *Pediculus.*

C. *pumila.*—Minute, quite smooth, slightly curved, elliptic-oblong; the border without any longitudinal lines. Length 1-1560th. Nordhausen.

C. *depressa.*—Minute, much depressed, elliptic; near the margin punctate. Striate. Length 1-1800th. On Cladophora.

C. *nigricans.*—Narrowly elliptic; densely aggregated; margin (limb) rather wide, entire, of a brownish-black colour, transversely striated; thirteen to fourteen striæ in 1-1200th. Length 1-1200th. On Conferva at Trieste.

Var *(b.)* C. *denudata.*—Limb wanting, also the transverse dotted striæ. Length 1-1320th.

C. *oblonga.*—Oblong-elliptic, apices rather acute, with longitudinal lines. Length 1-320th. On Conferva. North Sea and Indian Ocean.

C. *consociata.*—Broadly elliptic; disc mostly with radiating punctate striæ, thirteen on each side, with a central longitudinal hyaline line. Length 1-1320th. On Conferva. Baltic.

C. *aggregata.*—Oblong-elliptic, surrounded by a broad margin, which is lacerato-crenulate; disc, near the margin, with finely-dotted rays; and in the middle with dotted fine lines. Length 1-1440th. In Baltic and North Sea.

C. *nidulana.*—Elliptic-oblong, very smooth; on the side oblong-rectangular. Length 1-1320th. Coast of Normandy.

C. *striata.*—Of middling size; elliptic-oblong, transversely striated. Cuba, Mexico, United States.

C. *pinnularia.*—Rounded elliptic, the margin and disc (save the crenate longitudinal medium line) transversely striated. Florida coast.

C. *marginata.*—Elliptic; margin punctate (in older specimens with

radiating striæ), and with longitudinal central lines. Length 1-840th. On Marine Algæ. Adriatic.

COCCONEIS *Adriatica.*—Large, elliptic, with granular striæ, transverse on the disc; radiating on the margin. Length 1-696th to 1-480th. Trieste.

C. *Mediterranea.*—Size variable, elliptic or elliptic-oblong; disc regularly dotted; dots disposed both in transverse and in longitudinal lines. Length 1-840th to 1-552nd. Naples, Genoa.

C. *Peruviana.*—Elliptic; disc regularly punctate, with large puncta in fours, disposed at greater distances. Length 1-840th.

Genus COSCINODISCUS, (Ehr.)—Individuals solitary; lorica bivalve, discoid; surface of disc cellular, with or without a central spot or umbilicus; without processes or defined margin.

Coscinodiscus gives name to a family *Coscinodisceæ*, see page 308, which, together with the genus named, comprises *Actinocyclus* and *Actinoptychus*; it is a member of Kützing's tribe of *areolate* (cellular) *Diatomeæ*; so called from the cellular character of their valves.

Coscinodiscus approaches *Gallionella* (Melosira), but is distinguished by its cellular surface, and by not being concatenate.

The members of this genus occur both in a living and fossil state, and are marine in their habitat.

C. *patina.*—Large, with moderately-sized cells, disposed in concentric circles. The cells decrease in size towards the circumference. Fossil in the chalk marl of Zante, and alive in sea water at Cuxhaven. The young and vigorous specimens of live individuals are completely filled with yellow granules, whilst the older ones have an irregular yellow granular mass within them. Diameter 1-860th to 1-240th.

C. *radiatus.*—Large, marked with moderately-sized cells, disposed in lines, radiating from the centre; towards the margin the cells become smaller. A very abundant fossil in the chalk marl of Oran; alive, in sea water, near Wismar and Cuxhaven. Diameter 1-860th to 1-240th. (P. 14, figs. 39, 40.)

C. *Argus.*—Cellular; cells larger at the centre than at the circumference; the order of the rays often interrupted. This is

probably only a variety of C. *radiatus*. Fossil in the chalk marl of Caltanisetta and Oran, and living, in sea water near Cuxhaven. The cells of the discs, from Oran, vary very much in size. The granules are of a greenish colour in the living forms, which are very rare. Diameter of fossil 1-860th to 1-290th; living, 1-580th.

Coscinodiscus *eccentricus*.—Cells small, disposed in eccentric curved lines Found fossil in the chalk marl of Oran, in which condition, however, it is rare; but alive, it is met with abundantly in sea water near Cuxhaven and Vera Cruz. Locomotion not yet satisfactorily observed. Diameter 1-860th to 1-430th.

C. *lineatus*.—Cells small, disposed in a series of straight and parellel lines. Fossil in the chalk marl of Caltanisetta; alive at Cuxhaven. The cells in this species form parallel lines in whatever direction they may be viewed. In large and well-preserved fossil specimens as many as twenty-five openings were seen near the circumference. Within the live forms, sometimes numerous yellow vesicles are seen, as in *Gallionella*. Diameter of fossil 1-1150th to 1-480th; living, 1-1150th to 1-860th.

C. *minor*.—Small; cells small, scattered. Fossil in the chalk marl of Caltanisetta, Oran, and Zante; and alive in sea water near Cuxhaven. Diameter 1-1150th.

C. *Oculus-Iridis*.—Cells rather large, radiant; smaller near the centre and circumference. From five to nine large cells at the centre form a sort of star. Fossil in the chalk marl of Greece, and alive in sea water near Cuxhaven. This large species is curiously marked with coloured rings, which are apparently caused by the peculiar arrangement of the cells. This species differs from C. *centralis* in having larger cells; and from C. *asteromphalus* by its surface being unveiled, and its cells rather smaller. Diameter 1-240th.

C. *limbatus*.—Centre cells largest, not radiant; margin with linear rays, forming a striated rim (limbus). Diameter 1-576th. Fossil in Greek marl. The larger cells seven in 1-1200th.

C. *concavus*.—Each valve very concave; cells large, of equal size; four and a half in 1-1200th; not radiating. An African variety has seven to nine cells in 1-1200th. Richmond, Virginia.

COSCINODISCUS *flavicans*.—Small, with very small non-radiant cells, yellow by transmitted, but white by reflected light. Peru and St. Domingo.

C. gigas.—Very large; cells hexagonal radiant; central ones the smallest; marginal very large; rim striated. It is figured by Dr. Bailey. Cells five to six in 1-1200th near the margin. Fossil, Virginia. Alive at Cuxhaven.

C. *marginatus*.—Cells of nearly uniform size, imperfectly radiant in curved lines; the rim furnished with radiating lines of smaller cells. Cells nine to ten in 1-1200th. Fossil in Virginia. Alive at Cuxhaven.

C. *radiolatus*.—Cells very small, equal, and radiant. Eighteen in 1-1200th. Peru, Cuba, and Virginia.

C. *subtilis*.—Similar to the last, but with twenty-four cells in 1-1200th; and of uniform size.

C. *apiculatus*.—Cells slightly prominent and apiculate (pointed), rendering the surface rough: disposed in the manner of rays; ten in 1-1200th. Diameter 1-324th. Virginia. Has a general resemblance to *Pyxidicula gemmifera*.

C. *asteromphalus*. — Cells larger, seven to eight in 1-1200th, rather prominent, and in rays, decreasing in size towards the margin; a central stellate umbilicus; surface appearing as if overspread by a finely dotted membrane (veil.) Diameter 1-324th. Virginia.

C. *centralis*.—Differs by its smaller, equal, and radiating cells, which are twelve in 1-1200th; surface also not veiled. Has a similar central stellate umbilicus. Virginia and Sicily.

C. *velatus*.—Differs from the preceding by wanting the central stellate umbilicus. Cells angular; surface as if covered with a granular veil. Diameter 1-492nd.

C. *fimbriatus*.—Cells small, thirteen to fourteen in 1-1200th; imperfectly radiant and unequal; near the margin occurring in lines, and of smaller size. Diameter 1-324th. Caltanisetta, Sicily.

C. *perforatus*.—Cells small, evidently radiant, thirteen in 1-1200th; with a smooth central umbilicus, looking like a perforation; margin finely rayed. Diameter 1-348th. Virginia. Allied to C. *fimbriatus*, which, however, has not the smooth, central umbilicus.

COSCINODISCUS *punctatus*.—Cells very small, radiating; twenty-four to twenty-six in 1-1200th; loosely disposed at the centre, but dense towards the margin, which presents a broad, yellowish-white rim. Diameter 1-348th. Virginia.

C. *disciger*.—Differs from C. *perforatus* by its irregularly circular, not smooth, and larger umbilicus; cells very small, dotted, and very dense, indistinctly radiant; above thirty in 1-1200th. Virginia. Diameter 1-480th.

C. (?) *polystigma*.—Differs from C. *radiolatus* by its much larger radiant cells, fourteen in 1-1200th; rays converging, so as to form two indistinct whorls (zones), perforated, and disposed side by side. Diameter 1-360th. If a species of *Auliscus*? (p. 321) In the North Sea.

C. *heteroporus*.—Cells hexangular, smaller at the margin, and ten in 1-1200th; intermediate ones five to six in 1-1200th. Diameter 1-360th. Bermuda.

C. *omphalanthus*.—Large, cells radiating, those of the margin smaller, seven to eight in 1-1200th, whilst at the middle there are but six in 1-1200th; centre occupied by a rose-like stellate umbilicus, formed by seven to eight larger oblong cells. Diameter 1-96th. Bermuda.

C. *Apollinis*.—Surface covered with very dense punctiform tubercles, seventeen in 1-1200th, of equal size, and in rows radiating towards the margin. Diameter 1-432nd.

It differs from C. *Luna*, which it most nearly resembles, by the greater number and denseness of its rays, and by its larger size.

C. (?) *actinochilus*. — Centre of the disc occupied by punctate tubercles, densely radiated with an umbilicus; margin (rim) wide; irregularly dotted radiating lines (costæ) of the margin, smooth, and fifty-four in number. Diameter 1-408th. Not unlikely constituting a genus by itself.

C. *cingulatus*.—Disc with punctate tubercles, twenty-six in 1-1200th; dense, indistinctly radiant; a small clear umbilicus; margin with a strong annular band, capable of being detached. Diameter 1-552nd. Stands between C. *subtilis* and C. *gemmifer*.

C. (?) *Gemmifer*.—Disc with strong tubercles, loosely and elegantly radiant, ten in 1-1200th; a clear umbilicus. Diameter 1-456th.

Very like to *Pyxidicula gemmifer*, of Virginia, but a larger and more depressed form. It also approaches C. *cingulatus*.

Coscinodiscus *Luna*.—Disc covered with dense, punctate tubercles, equal, radiant, but becoming, towards the margin, loose and unequal. It is nearest to C. *Apollinis*.

C. *granulatus*.—Small; cells very small, giving a granular appearance to the disc; dense, and disposed in rows; eighteen to twenty-one in 1-1152nd. Diameter 1-552nd. Fossil, Virginia.

C. *spinulosus*.—Testule flattened, surface finely porous; margins of pores spinous; spines and pores about twelve in 1-1152nd. Diameter 1-576th. Fossil, Patagonia.

C. *minutus* (Kütz.)—Margin with dotted rays; disc nearly smooth. Diameter 1-1416th.

C. *minor*.—Margin smooth; disc irregularly and densely punctato-cellular. Diameter 1-1150th to 1-576th. Fossil in chalk marl, Greece, Sicily, Peru, &c. Alive, Cuxhaven,

C. *striatus* (Kütz.)—Margin striated with radiating lines; disc cellular; cells of centre without order. Diameter 1-456th. Cuxhaven.

C. *cinctus*.—The striæ of the external rim radiating, but broken at their middle; central cells closely aggregated, those around loosely so. Diameter 1-324th. Alive, Cuxhaven. Fossil, Richmond, Virginia.

C. *cruciatus* = *Pyxidicula cruciata* and *Pyxidicula Hellenica* (Ehr.)—Cells hexagonal, arranged in straight, parallel lines, with a smooth annular rim.

Genus Craspedodiscus.—Shell composed of two equal orbicular valves, not in chains; surface cellular, cells having a radiating arrangement; otherwise not radiated nor divided by septa, but with a sculptured tumid margin, of a different structure, and separable.

Has the habit of *Coscinodiscus*, with an elegantly sculptured margin (rim.) It differs from *Coscinodiscus limbatus* and similar forms, by its margin not becoming gradually lost in the disc, nor being a mere boundary to it of the same structure; but, on the contrary, separated from it by a distinct furrow, and having a different structure. This border is either developed at the first, or the being exists primarily as a *Campylodiscus*, the rim being a gradual production.

Pyxidicula Coscinodiscus, of Virginia, would seem to be a member of this genus.

Craspedodiscus *elegans*.—Disc large, central cells radiant, seven in 1-1200th; five to six larger oblong ones constitute a central umbilicus; margin tumid, 1-1152nd wide, with larger obliquely quadrate cells, six in 1-1200th. Diameter 1-132nd. Bermuda (P. 14, f. 38.)

C. *Coscinodiscus* = *Pyxidicula Coscinodiscus.*—Central cells of the disc small, decreasing towards the centre, seventeen to eighteen in 1-1200th; no umbilical star; cells of the margin larger, unequal, hexagonal, about ten to eleven in 1-1200th. Diameter 1-396th. Richmond, Virginia. The rim of this species is wider than that of the preceding.

Genus Cyclotella (Kütz.)—Individuals solitary or binate, disciform, orbicular; the primary side distinct, forming a ring; the secondary plane. Lorica bivalve, valves plane, orbicular, conjoined by an interstitial ring.

Sect. I. *Individuals included in an amorphous gelatinous substance, (Discoplea,* Ehr.)

C. *operculata* = *Discoplea Kützingii* (Ehr.) = *Pyxidicula operculata.* Secondary sides dotted on the margin. Diameter 1-1020th. Common in fresh water.

C. *Meneghiniana.* — Secondary sides striated on the margin. Diameter 1-1440th. Berlin.

Sect. II. *Individuals adnate* (free.)

C. *Scotica.*—Small, quite smooth. Diameter of the plane disc 1-960th. On Conferva, Coast of Scotland (P. 17, f. 17.)

C. *ligustica.*—Of middling size, quite smooth, adnate or free. Diameter of plane disc 1-720th to 1-516th. On filiform Algæ, Genoa.

C. *maxima.*—Large, minutely punctate, adnate. Diameter of the nearly plane disc 1-300th to 1-126th. On Polysiphonia, Coast of Peru, Chili.

C. (?) *minutula.*—Small, with radiating and flexuose striæ on the secondary side. Diameter 1-1200th. Fossil in Luneberg. It may be but a separated segment of *Melosira.*

C. (?) *Rotula*—Rather small; secondary side with radiating striæ, and a dotted centre; one side convex, the other concave. Diameter of

disc 1-480th. Fossil in the Elbe deposits. Probably a segment of *Melosira arenaria*.

Cyclotella (?) *Kützingiana* (Thwaites.)—Frustules (cells, on primary side sigmoid, flexuose; on secondary side with radiating striæ. The frustules of this species are short, and have an apparent sigmoid curvature, which is due to each of their striated, disciform ends, having a prominence on one side of its centre, and a depression on the other, and the opposite end of the frustule having a depression and prominence corresponding to these. The sporangia are developed much in the same way as in *Melosira*. This species is closely allied to C. (?) *minutula* (Kütz.), but differs in the curvatures apparent in the frustules. It occurs in brackish water, near Bristol. (Ann. N. H. 1848, p. 169.)

Genus Cymatopleura (Smith).—Valves undulated, margins not produced into alæ. Frustules free, solitary, or, when undergoing self-division, in pairs.

It has the habit of *Surirella*, but the undulated surface of the valves seems to indicate a peculiarity of structure sufficient to constitute a generic difference, and the absence of alæ and costæ implies a further diversity in the internal character, which cannot be regarded as unimportant, (Ann. Nat. Hist. p. 12. 1851.)

C. *solea* = *Surirella librilis* (Ehr. P. 18, f. 9, a lateral view.)

C. *elliptica* = *Surirella elliptica* (Kütz.)—Frustules on front view oblong, linear; on side view broadly elliptical, surface of the valves with about four undulations, obscurely striated. Length 1-350th to 1-200th. Breadth about half the length. Fossil and alive in slow streams or ponds with *Oscillatorieæ* (P. 18, f. 7, 8.) It is very variable in size, the fossil specimens being usually twice as large as the recent frustules. Both extremities of the valves are somewhat pointed.

C. *Hibernica*.—Frustules on side view orbicular, with prominent, somewhat pointed extremities; surface of valve with about three undulations obscurely striated. Length 1-370th to 1-220th. Breadth two-thirds the length. River Bann, Ireland.

Genus Cymbella (Kütz.)—Individuals solitary or geminate, free (neither adnate nor included), unequally curved; one primary side,

the internal and ventral, narrower than the other, the external or dorsal; secondary sides equal, transversely striated, the median apertures of the margins approximate.

This genus includes species distributed in the genera *Syncyclia*, *Cocconema*, *Navicula*, and *Pinnularia*, of Ehrenberg's system.

Its free unattached forms have an affinity, some with *Epithemia*, others with *Navicula* and *Amphora*, but differ from those genera by their median ventral aperture, and by their unequal dorsal aspect. *Cymbella* has also an affinity with the genera *Gomphonema*, *Encyonema*, and *Schizonema*, from which also it may be distinguished by the characters named.

CYMBELLA *Ehrenbergii* = *Navicula inequalis* (Ehr.)—Large, unequally and broadly lanceolate; apices rather produced, and somewhat obtuse; transverse striæ punctate, twelve in 1-1200th (P. 3, f. 154.) Length 1-216th. Berlin. Fossil, San Fiore.

C. *heteropleuia* = *Pinnularia heteropleura* (Ehr.)

C. *cuspidata.*—Small, rather wide in proportion; apices produced and slightly acute; transverse striæ fine, sixteen to eighteen in 1-1200th. Length 1-576th. Fossil, Luneberg,

C. *obtusiuscula.*—Small, elliptic, lanceolate; apices not produced, rather obtuse; transverse striæ fine, eighteen to twenty in 1-1200th. Length 1-600th.

C. *gastroides.*—Large, sublunate, unequal, thickened at the middle, but tapering towards the obtuse ends; transverse striæ granular, eleven to twelve in 1-1200. Length 1-288th to 1-216th (P. 17, f. 18, 19, 20.) Fresh water, Germany.

Var. *(b.)*—Apices broadly truncate.

C. *maculata* = *Cocconema lunula* (Ehr.)—Small, lunate, tapering at each end; obtuse; primary side elliptic, truncate; transverse striæ, twelve to thirteen in 1-1200th. Fresh water, America.

C. *Helvetica.*—Large, slender, elongate; ventricose at the middle, but tapering towards the rather obtuse extremities; oblong on the primary side, dilated at the middle, and truncate at each end; transverse striæ fine, very beautifully granular; thirteen to fourteen in 1-1200th. Length 1-264th to 1-240th. Thun, Switzerland (P. 17, f. 24 to 28.)

C. *gracilis* = *Cocconema gracile* (Ehr.)—Small, slender, lunate;

attenuated at each end, apices somewhat acute; primary side larger, linear-oblong, and ends rounded, truncate; transverse striæ very slender, seventeen in 1-1200th. Length 1-840th to 1-600th. At Thun.

CYMBELLA *Leptoceros* = *Cocconema Leptoceros* (Ehr.) — Minute; acute at the ends; inflated at the centre; primary side large, oblong-elliptic, rounded at the ends; striæ seventeen in 1-1200th. Falaise and America.

C. *affinis* = *Cocconema Fusidium* (Ehr.)—Minute, somewhat obtuse at each end; dorsum more prominent, with large terminal apertures, primary side larger, oblong-elliptic; transverse striæ distinct; nineteen in 1-1200th. Alive, Falaise, Schleswig. Fossil, America.

C. *ventricosa*.—Minute, rather obtuse at each end, dorsum prominent, rounded; venter plane, terminal apertures distinct, large, hyaline; primary side oblong, truncate; striæ indistinct. Length 1-1000th. Fresh water.

C. *excisa*.—Rather small, dorsum prominent, convex; venter with a central notch; apices produced, slightly recurved, obtuse; transverse striæ sixteen in 1-1200th. Length 1-840th. On Oscillatoria, Trieste.

C. (?) *Pediculus*.— Very smooth, small, lunate; dorsum convex; venter rather concave; ends somewhat acute. The other aspect elliptic truncate. Common. Parasitic on Conferva.

C. (?) *flexella*.—Small, smooth, secondary side elliptic, subsigmoid, apices rather produced, but obtuse; on the other aspect curved, convex; venter concave, notched (excised), ends truncate. Length 1-650th. At Thun, Switzerland. This species probably corresponds to *Navicula Semen*, (Ehr.)

Genus DENTICELLA (Ehr.)—Generic characters unknown.

This genus is not recognised by Kützing, who retains its species mostly in *Odontella*, with which they were originally classed by Agardh. Its affinities are with *Isthmia*, *Biddulphia*, and *Zygoceros*.

D. *aurita*.

D. *fragilaria*.

D. *gracilis*.—Finely striated transversely; width greater than the length; laterally constricted nearly to the central band; chain 1-1152nd in width. The length of D. *aurita* exceeds the breadth, but both are compressed, and tridentate on the sides, with a dorsal

and ventral hook in the middle of the sides, and two apertures at the angles.

Denticella (?) *tumida.*—Testules turgid (subglobose) without lobes or septa; surface minutely dotted; with two long exserted (projecting) tubules and setæ on each side. Diameter 1-960th. Bermuda.

D. *lævis.*—Has the habit of D. *aurita,* but with a smooth tridentate testa. Diameter 1-432nd. Antarctic Sea.

D. *Biddulphia.*—Sculptured. In habit and surface resembles *Biddulphia pulchella,* but has long setæ disposed midway between the contiguous halves. It has three cells, and two septa to each lateral segment. (P. 13, f. 48.) Cuba, Peru.

D. *Rhombus.*—Surface, with very minutely dotted lines: resembles *Zygoceros Rhombus,* but is provided on each side, at the middle, with a sharp hook. Diameter 1-312th. Petersburg, Virginia.

The band (zone) on the dorsum, like as in *Zygoceros,* is not smooth, but adorned with rows of minute dots (puncta.)

D. *tridentata.*—Has the habit of *Biddulphia tridentata,* but the aculei of a *Denticella.* Diameter 1-480th. Virginia and Maryland.

D. (?) *polymera.*—Testules very broad, with ten to twelve septa and lobes; surface granular; six granules on the anterior surface of the central lobe, disposed in the form of a star; spiny denticles on the sides, not in the median line; tubules of the apertures projecting some distance. Length 1-132nd. Bermuda.

Genus Denticula, (Kütz.)— Free, solitary, or binate; linear-oblong on the primary side; the secondary transversely striated or costate; striæ very distinct.

This genus, named by Kützing, is placed in the family *Fragilarieæ,* Its members known to Ehrenberg, were described by him, some among *Fragilaria,* others with *Bacillaria, (Diatoma). Denticula* approaches *Surirella* and *Navicula.*

D. *tenuis.*—Narrowly linear, margin finely punctate; secondary side minutely striated, narrowly lanceolate; transverse striæ ten to eleven in 1-1200th. Length 1-1080th. Among Conferva at Nordhausen.

D. *frigida.*—Oblong, small, margin finely striated; secondary side linear lanceolate; transverse striæ eleven to twelve in 1-1200th. Length 1-1200th. Cold Alpine streams, Thun, Switzerland.

DENTICELLA *thermalis.*—Oblong or subtrapezoid, margin beautifully dotted; secondary side lanceolate; transverse striæ seven to eight in 1-1200th. Length 1-660th. Hot baths of Abano.

D. *elegans.*—Oblong, with obtuse angles, rather dilated at the centre; margin with minute prominences; secondary side linear lanceolate; transverse striæ six in 1-1200th. Length 1-660th. Nordhausen. (P. 16, f. 4.)

D. *obtusa.*—Oblong, large, margin striated; secondary side lanceolate; ends obtuse; transverse striæ eleven in 1-1200th. Length 1-336th. Sweden, Norway, Jutland.

D. *constricta* = *Navicula* (?) *constricta*, (Ehr.)—Oblong, large, margin dentate; apices dilated, rounded; secondary side transversely ribbed, oblong, equal; each end rounded and truncate; three to four costæ in 1-1200th. Length 1-216th. Berlin. (P. 16, f. 3.)

D. *undulata* = *Navicula* (?) *undulata* (Ehr.)—Very large, oblong, rectangular; margin dentate; remarkable by a pair of dotted longitudinal flexuose lines; secondary side elliptic, apices rounded; transverse costæ four in 1-1200th. Length 1-144th. Berlin. (P. 3. f. 149.)

Genus DESMOGONIUM, (Ehr.)—Characters unknown.

D. *Guianense* occurs fossil, and in meteoric dust. From Ehrenberg's figures (P. 24. fig. 13), of this species, *Desmogonium* would seem to belong to the family *Naviculeæ;* it appears, however, to possess no foramina.

Genus DIADESMIS, (Kütz.)—Individuals navicula-shaped, conjoined so as to form elongated (biconvex) bands, with one median aperture and two terminal ones, distinct. It is a member of Kützing's family *Naviculeæ.* Ehrenberg has described two of the species with *Tabellaria*, and a third with *Navicula.* It closely resembles *Fragillaria*, from which it differs in its frustules having a median umbilicus.

D. *conferracea.*—Smooth; length of each individual frustule, *i. e.*, the width, when conjoined in a filament, double that of its shorter diameter; lateral junction surfaces lanceolate and acuminate at each end. Length 1-960th. Among Conferva, Trinidad. (P. 17. f.. 32, 33.)

D. *lævis* = *Tabellaria lævis* (Ehr.)—Smooth; length three to four times the breadth. Chili.

DIADESMIS *sculpta* = *Tabellaria sculpta* (Ehr.)—Margin striated. Chili.

D. (?) *Bacillum* = *Navicula Bacillum* (Ehr.)—Segments striated, linear-oblong, rounded at each end, central aperture large, oblong. Fossil.

Genus DIATOMA (Ag.)—Individuals linear, quadrangular, symmetrical; at first conjoined in bands, but ultimately separated to such an extent, that they are connected only by a more or less distinct, jelly-like link, *(isthmus)* extending between their angles,—generally the alternate ones. The filaments are flat or compressed. (Kütz.)

Diatoma differs from *Tabellaria*, (see that genus) *Grammatophora*, and *Rhabdonema*, by its frustules wanting longitudinal bands *(stripes)*; and from the two first also, by the absence of a central aperture. From *Fragilaria* it is distinguished by the angular and zig-zag concatenation of the frustules. Kützing says its filaments are often attached. He makes it a member of the family *Fragilarieæ*.

Ehrenberg describes the species of *Diatoma*, (Kütz.) some with *Fragilaria*, others with *Bacillaria*. The latter is, however, nearly equivalent with *Diatoma*, (Ag.) as understood by Kützing; to convey his views, at the risk of repetition, the characters of *Diatoma* presented by that observer are given. It may be observed, that Kützing admits a genus *Bacillaria*, which is represented by one species, *Bacillaria paradoxa*; he places it in his family *Surirelleæ*. The reason he assigns for instituting this genus, is, that in *Bacillaria*, the striæ (seen in an end view) are interrupted in the middle by a clear longitudinal band, which is not the case in *Diatoma*.

The genus *Diatoma* of Mr. Ralfs, would appear to correspond with *Bacillaria* of Ehrenberg, and with the genera *Diatoma* and *Bacillaria*, of Kützing. Mr. Ralfs enumerates the following characters and marks of distinction between it and allied forms. Filaments flat or compressed, free frustules quadrangular, partially separating, and cohering by the angles, generally by the alternate ones. This genus is distinguished from *Exilaria*, *Striatella*, *Achnanthes*, and *Isthmia*, by its unattached filaments; from *Biddulphia* by the angles not being produced, and from *Fragilaria* by the connection of the frustules by their angles, in a zig-zag chain.

Sect. I. *Forms quite smooth.*

DIATOMA *pectinale*.—Segments laterally acutely lanceolate, according to Kützing it = *Bacillaria seriata*, B. *Ptolomæi*, and B. *flocculosa* (Ehr.) Length 1-720th.

D. *vitreum*.—Filaments attached by a very delicate stalk, and made up of few segments; segments miuute, oblong, glass-like; with a longitudinal row of punctiform spaces. It is very closely allied to D. *minimum*, Ralfs. Length 1-1320th. On Algæ in the Adriatic.

D. *hyalinum*.—Segments larger, elongated, very slightly attenuate at each end; peculiarly hyaline; lateral aspect lanceolate, rather obtuse; with golden yellow interspaces. Length 1-336th. Adriatic.

Sect. II. *Forms striated.*

D. *vulgare*.—Filaments long, attached by an almost invisible stalk; segments rectangular, convex, striatedo n the margin; punctate at each end; three to four times longer than broad. It = *Bacillaria flocculosa* and B. *vulgaris* (Ehr.) (P. 3, f. 168.) Length 1-420th. Pools and streams. Common.

D. *mesodon*.—Segments oblong, with a few central dentations, laterally ventricose, lanceolate, with three to four transverse striæ at the middle.

Var. (*b*.)—Segments quadrate.

Var. (*c*.) *cuneatum*.—Segments cuneiform. It = *Bacillaria cuneata* (Ehr.) (P. 3, f. 170.)

D. *tenue*. — Attached, stalk very indistinct; joints laterally lanceolate, with transverse striæ; twelve in 1-1200th. The form and size of the segments vary.

Var. (*a*.) *moniliforme*.—Joints quadrate.

Var. (*b*.) *intermedium*.—Diameter of joints twice the length.

Var. (*c*.) *cuneatum*.—Segments cuneate.

Var. (*d*.) *normale*.—Joints elongate, slender.

Var. (*e*.)—Segments obliquely united. = *Bacillaria pectinalis* (Ehr.) Length 1-660th.

D. *mesoleptum*.—Attached, stalk obsolete; segments rather contracted at the centre, laterally lanceolate; transverse striæ ten to eleven in 1-1200th. Length 1-650th. Fresh water.

D. *elongatum*.—Attached, stalk obsolete; segments very slender, rather narrower at the middle; laterally linear, tumid, and capitate

at each end, connected in a chain by a short filiform isthmus; striæ seven in 1-1200th. Fresh water. Length 1-288th. This species is described by Mr. Ralfs, thus,—"Frustules plane, several times longer than broad; front surface with the ends dilated."

DIATOMA *Ehrenbergii.* = *Bacillaria elongata* (Ehr.) — Attached, stalk minute; segments strong, rather contracted at the centre; laterally dilated at the middle, and contracted near the capitate ends; concatenated by a distinct isthmus. Length 1-456th. Germany. (P. 3, f. 169.)

D. *stellaris* (Bailey.)—Frustules rectangular, many (eight) times longer than broad, usually in groups of five or six individuals, cohering by the adjacent (not alternate) angles, so as to produce stellate groups of minute frustules. Common from Rhode Island to Florida.

Genus DICLADIA.—Lorica bivalve, not concatenated; unilocular; valves unequal, one simple and turgid, the other two horned; the cornua sometimes branching.

In form this genus approaches *Rhizoselenia.* In respect to its position in the family *Bacillaria,* Ehrenberg appends a note of interrogation.

D. *Capreolus.*—Smooth, bifurcate at one end. Diameter 1-960th. Virginia.

D. (?) *clathrata.*—Smooth, with intersecting lines, (latticed); remarkable by its rounded outline, and two unequal frontal horns. Diameter 1-960th. Virginia.

D. *attenuata.*—Smooth, with two simple horns at one end, with some parallel, long, acute, and jointed corniculi (setæ) about their base, resembling *antennæ:* the other end unknown. Antarctic Sea.

D. *bulbosa.*—One end with two simple horns, with corniculi diverging at the base, but converging at the apex; bulbous in the central part and rather sulcate (furrowed); the other end unknown. Diameter of a fragment of the one valve 1-782nd. Antarctic Ocean.

Genus DICTYOLAMPRA (Ehr.)—Bivalve; orbicular, not concatenate; disc not perforated; internal septa absent; valves equal, cellular only at the centre, their margin radiated, but otherwise smooth.

From these characters this genus would seem to be closely allied to *Coscinodiscus* and *Craspedodiscus;* to differ from the former by the

external portion or margin of the disc not being cellular, and from the latter by the absence of a distinct marginal figured zone or rim.

Dictyolampra *Stella.*—Characters unknown.

Genus Diploneis.—Vide *Pinnularia.*

Genus Discoplea (Ehr.)—Characters unknown.

This genus has a close affinity with *Pyxidicula;* it is in part equivalent to *Cyclotella* (Kütz.), (p. 341,) one of the two sections of which, in this author's system, distinguished by being included in a gelatinous mass or nidus, has, indeed, the term *Discoplea* applied to it.

D. (?) *græca.* = *Coscinodiscus (?) græcus* (Kütz.) Disciform, on plane sides, interruptedly striated in a radiating manner. Diameter 1-864th. In Greek marl.

D. *Kützingii.*—Smaller, disciform; radiant striæ present only along the margin of the plane sides.

D. *dendrochæra.*—Small, tumid in front; margin of disc, and also the centre, smooth; the latter, however, with a minutely striated ring surrounding it. The rays of the central coronula (circlet) about ten in number. Diameter 1-1920th. Found on the roots of plants from the mountains of Venezuela? Habit of D. *compta.*

D. (?) *Americana.*—Turgid, with the habit of a compressed *Gallionella* or *Pyxidicula;* the dorsum with three transverse keels; the lateral disc dotted in the middle. Diameter 1-660th. Virginia, Maryland.

D. (?) *Actinocyclus* = *Pyxidicula (?) Actinocyclus.*

D. (?) *astræa.*—Large, flat; lateral margin densely rayed; centre dotted. Diameter 1-636th. Kurdistan. It has the habit and size of *Gallionella varians,* with the peculiar central granules; but not being met with in chains, seems nearer *Discoplea.*

D. *compta.*—Slender, tumid in front; a crown of striæ on the side near the margin; and a remarkable central agglomeration of granules. Habit of D. *Americana,* but smaller.

D. *denticulata.*—Surface beset with a peculiar, straight, and parallel row of small cells or granules, ten in 1-1152nd; margin dentated. Diameter 1-672nd. Bermuda. In the character of its margin it resembles *Gallionella sulcata,* but by the cells of its disc approaches *Coscinodiscus lineatus.*

Discoplea (?) *undata.*—Surface covered by minute granules in radiating series; margin undulate, with fifteen sinuosities. Diameter 1-576th. Bermuda.

D. (?) *Peruana.*—Surface of disc rayed; five fine rays reaching as far as the centre. The thickness of the bivalve testule equals half its width. Has the habit of D. *astræa*, and of *Gallionella varians*. Diameter 1-600th. Found in the pumice from Arequipa and Santiago, Peru.

D. (?) *Rota.* — Disc large, surface unequally papillose; central papillæ largest; margin with fifty-two equal rays not attaining the centre; their intervals occupied with scattered papillæ. Diameter 1-192nd. It approaches *Actinoptychus dives*, to which, along with the ensuing species, it may be perhaps united in a new genus. A gelatinous envelope is not apparent; and true septa are wanting.

D. (?) *Rotula.*—Disc smaller than the preceding, covered with small scattered and equal papillæ; margin with twenty equal rays not reaching the centre. Diameter 1-696th. Southern Ocean.

D. (?) *dives* = *Actinoptychus dives* = *Cyclotella dives* (Kütz.)—Is remarkable by the rows of papillæ in the intervals of the rays, and the smaller ones at the centre. Diameter 1-812th.

D. (?) *Coscinodiscus.*—Small; disc irregularly but densely and finely granular; margin smooth. Habit of *Coscinodiscus minor*, rather turgid on the side. Diameter 1-1728th. Fossil, New Hampshire.

D. (?) *physoplea.*—Small; disc and margin smooth; with a circumscribed centre to the disc, bearing twelve large, vesicular-looking granules; limb, broad and smooth. Diameter 1-1152nd. Fossil, Virginia.

D. *mammilla.* — Smooth, thick, nummiform (money-shaped), suture of the valves tumid; centre of the disc of each valve raised as a boss (umbo); marginal ring vanishing; suture dentated on the side of each valve. Diameter 1-864th. Fossil on the coast of Patagonia.

D. (?) *cingulata.*—A fossil species from Ægina, so named by Ehrenberg.

D. *radiata.*—Also a fossil species from the same locality.

D. *atmospherica.*—Margin of disc plane, with broad and equal radiations; central portion rather turgid and granular, narrower than the striated border; the granules and the striæ becoming con-

fluent. Diameter 1-1008th.; forty rays in discs 1-1152nd, wide; in a few instances the rays and granules have not run together. Found in dust wafted about in the air. (P. 24, f. 1, 2.)

Discoplea *sinensis*.—Margin of disc plane, with equally disposed rays; central part rather turgid and granular, narrower than the striated border; with the striæ and granules always separate, and circumscribed by a rim. Diameter 1-864th.; ninety-two rays in discs 1-1152nd. broad; the rays are smooth, not rough as in D. *atmospherica*. China. (P. 24, f. 4.)

D. *atlantica*.—Smaller; central part rather granular; rays equally disposed, but not circumscribed so as to represent a rim as in the preceding. (P. 24, f. 3.)

Genus Endictya.—Lorica bivalve, not in chains, subglobose, no apertures on the surface; valves equal, simply bordered, not contiguous nor dentate, but with an intermediate cellular portion. These forms are *Coscinodisci*, with the discs separated laterally by an intervening cellular structure; or they may, otherwise, be considered *Dictyopyxides*, with the valves not contiguous, but disjoined by the peculiar cellular band named.

E. *oceanica*. — Large, disc and sides elegantly but irregularly cellular; the cells of disc, however, are almost concentric in arrangement, and seven in 1-1152nd. Diameter 1-528th. Fossil in African Guano.

Genus Entomoneis.—Simple, not in chains; valves equal, quadrangular, smooth, with a distinct round umbilicus; apertures terminal, placed not laterally but quite at the extremities of the truncate ends.

Entomoneides are smooth Diploneides or Naviculæ, constricted at the middle, and having true terminal apertures. It differs from *Amphiprora*, by the absence of striæ.

E. *alata* = *Navicula alata*.—Laterally navicular, obtuse; dorsally deeply constricted at the middle, with wide, truncate extremities; margin expanded or alate (winged), very transparent, central portion with longitudinal lines; movements active (P. 16, f. 5, 6, 7.) Length 1-570th to 1-430th. North and Baltic Seas.

Genus Entopyla (?) Sect. *Echinellæa*. — Lorica prismatic, compressed, multivalve, free, or in chains. Valves straight, contiguous, in regular series like the leaves of a book, with a large central aper-

ture traversing the interior; the exterior lamina dissimilar, marked by transverse lines; one external valve quite entire, the other with a large pore at each apex.

This genus, in being curved, approaches *Achnanthes*, but, by its external and tabellar form, is still nearer *Tessella;* its closest affinity is with *Biblarium*, which it resembles in internal structure. It occurs in quadrangular tablets or boxes, made up of several lamina, like the leaves of a book, but firmly connected. The lamina or leaves are parallel with the narrow sides, and curved: the outermost leaflet on each side is thicker, like the cover of a book, and marked with thirty-two horizontal striæ. These two outer sculptured lamina do not resemble each other as in *Biblarium*, for one is concave, and the other convex; the concave one constitutes the ventral surface, and has two large, round apertures at its two ends; whilst the other (cover or dorsum) possesses no opening. The including or intervening leaves have each a large opening in the centre, and, consequently, but a narrow margin is left; and the little tablets, or boxes, have a continuous cavity in their interior, such as also occurs in *Biblarium*. The sculptured covers have a considerable resemblance to *Surirella*.

Eutopyla *Australis*.—Linear, rounded at each end, in adult condition with sixteen intermediate leaves, in young specimens often but six; external leaves (covers) marked (in the full grown state) by forty striæ (costæ), bisected by a flexuous line, as in *Surirella*. Length 1-240th. In 1843 Ehrenberg described this species under the name of *Surirella* (?) *Australis*. Found in Patagonian Guano.

Genus Epithemia (Kütz.)—Transverse section of lorica trapezoid, transverse striæ strongly marked, granular or moniliform. Locomotion has not been observed. Both the upper and under surfaces are traversed by two longitudinal lines, terminated at each apex by a pore. It belongs to the family *Eunotiæ*, and differs from *Navicula*, *Cocconeis*, *Amphora*, and *Cymbella*, by wanting a central opening, and from *Fragilaria*, by its two sides being unlike, one being concave, the other convex. Habitat, sea-water, on marine Algæ.

E. *Sorex*.—Minute, dorsum very convex, apices prominent, acute; striæ onvergent, twelve in 1-1200th; figure on the primary side

elliptic, and apices, though prominent, are rather obtuse. Length 1-960th.

EPITHEMIA *Musculus*.—Dorsum elevated, apices somewhat acute, striæ convergent, ten to eleven in 1-1200th; primary sides broadly elliptic, subrotund, apices slightly prominent. Length 1-420th. Brackish water in the Baltic (P. 16, f. 18.)

E. *Westermanni* = *Eunotia Westermanni* (Ehr.)—On secondary side dorsum convex, apices gradually tapering, rather obtuse, not prominent striæ scarcely convergent in the central portion, seven to eight in 1-1200th; on primary side elliptic. Length 1-360th.

E. *Zebra* = *Eunotia Zebra* (Ehr.)—Dorsum convex, apices very obtuse; transverse striæ of the centre convergent, five to seven in 1-1200th; primary side oblong. Length 1-360th.

E. *Zebrina* = *Eunotia Zebrina* (Ehr.)

E. *turgida* = *Eunotia turgida* (Ehr.)

E. *Porcellus*.—Large; on secondary side, dorsum convex; apices truncate, reflected; transverse striæ convergent, eleven in 1-1200th; primary side linear, seven times longer than broad. Length 1-240th to 1-216th. Fossil at San Fiore (P. 16, f. 12.)

E. *Alpestris*.—Secondary side arcuate, narrow; apices rounded, very slightly recurved; transverse striæ four to five in 1-1200th; primary side unequal. Length two to three times greater than width. (1-600th to 1-324th. P. 16, f. 8.) Spring water, Thun, Switzerland.

E. *ocellata* =*Eunotia ocellata* (Ehr.)

E. *Argus* = *Eunotia argus* (Ehr.)

E. *gibberula* = *Eunotia gibberula* (Ehr.)

E. *Textricula* = *Eunotia Textricula* (Ehr.)

E. *Saxonica*.—Small, on secondary side dorsum convex, under side concave, contracting gradually towards the ends, which are slightly obtuse, rounded but not recurved; transverse striæ subconvergent, six to seven in 1-1200th; primary side oblong, rectangular. Length 1-840th. Saxony and Italy.

E. *proboscidea*. — Small; on secondary side dorsum expanded, rather concave below; apices constricted, obtuse, remarkably recurved; transverse striæ convergent, five to six in 1-1200th; primary side oblong, rectangular, with obtuse angles. Length 1-540th. Fossil, Luneburg.

EPITHEMIA *librile* = *Eunotia librile* (Ehr.)

E. *gibba* = *Eunotia gibba* (Ehr.)—Large, straight, on secondary side, dorsum gibbous at its middle; apices rounded, very obtuse; transverse striæ parallel and very close; on primary side, inflated at both ends. Length 1-144th.

E. *ventricosa.*—Straight; on secondary side, dorsum gibbous at its centre; apices very obtuse, rounded; transverse striæ parallel, close, thirteen to fourteen in 1-1200th; on primary side ventricose at the middle. Length 1-450th. Germany.

E. *granulata* = *Eunotia granulata* (Ehr.)—Large; on secondary side slightly arcuate, dorsum convex, apices rounded, very obtuse, recurved, transverse striæ moniliform, six in 1-1200th, their interstices very finely punctate; on primary side, elongated, straight, linear. Length 1-144th.

E. *Faba* = *Eunotia Faba* (Ehr.)—Large, on secondary side slightly arcuate, dorsum convex; apices but very little recurved, obtuse; striæ moniliform, seven to eight in 1-1200th, their interstices very delicately punctate; primary side oblong, dilated at the middle Length 1-180th. Fossil.

E. *vertagus.*—Large, on secondary side slightly arcuate; dorsum convex, with rounded and reflexed apices; striæ transverse convergent, ten in 1-1200th, their interstices punctate; on primary side oblong, rather dilated at the centre. Length 1-168th. Normandy.

E. (?) *cingulata* = *Eunotia cingulata* (Ehr.)

Genus EUMERIDION (Kütz.) Cuneiform, prismatic, trapezoid, conjoined in a wand or convoluted band, at length stalked. Striæ transverse, strong, unbroken.

Kützing has created this genus in the belief that *Meridion constrictum* (Ralfs) possesses characters not belonging to *Meridon,* and such as are sufficient to separate it.

The bands developed, resemble, generally, in their convolution, those of *Meridion,* but Kützing states that the transverse section of the frustules is trapezoid, and that they are attached, like species of *Synedra,* by a short, thick, gelatinous pedicle.

E. *constrictum* = *Meridon constrictum* (Ralfs.)

Genus EUNOTIA.—Lorica prismatic, striated, composed of one, two, or more pieces or valves. Lower or ventral surface flat, or rather

concave, dorsal convex, and often dentate, with two apertures at each apex; lateral surfaces plane. Self-division complete, and hence the frustules are always solitary, or in pairs, during the process of fission. Found both living and fossil. Habitat, freshwater, parasitic on Algæ.

Eunotia is closely allied to *Navicula,* but differs in the absence of a central opening (umbilicus.) The cross section of the lorica is trapezoid, and the transverse striæ are uninterrupted, *i. e.* unbroken, "The frustules are simple or binate, quadrangular."

Eunotia are mostly found attached, by their concave surface, to various fresh water Algæ.

"Some species," says Mr. Ralfs (Ann. Nat. Hist. 1844, p. 459), placed by Ehrenberg in this genus, have cymbiform frustules, and belong to Agardh's genus *Cymbella.*

"In Eunotia the frustules resemble those of some species of *Fragilaria,* but are not united into a filament. Viewed laterally the frustules are lunate. The convex dorsal surface is generally raised in transverse ridges (dentations, Ehr.); and the number of these ridges, as seen in a lateral view, when they appear like teeth, distinguishes the species. Prof. Bailey suspects that the number of these teeth is liable to variation, and that the number of species has, in consequence, been made too great."

Besides multiplying by self-division, the *Eunotiæ* have been observed by Mr. Thwaites, and others, to propagate by conjugation. (P. 14, f. 1 to 8.) Frustules developed in the latter mode are larger than the parent beings producing them, and in their early stage are surrounded by mucus, and not striated. Where the number of dentations is equal in two forms, and so cannot furnish a specific character, then the variations in the figure of the lorica generally, and particularly of its apices, are employed.

Eunotia *turgida.* = *Epithemia turgida* (Kütz.)—Lorica semilanceolate; ends truncate; striated; striæ eight in 1-1200th. Dorsum convex. A longitudinal furrow runs along the middle of each side; scarcely visible in living specimens, owing to the colour of the body. (Group 157, P. 3, and f. 158, 159, 160, and 161, P. 14, f. 1 to 8.) Found upon Vaucheria and Conferva. Length 1-1150th. to 1-240th.

Eunotia *Westermanni.* = *Epithemia Westermanni* (Kütz.)—Semi-lanceolate, oval, with ten striæ in 1-1200th. It is of a rich ochre colour. (In group 157.) Found with the preceding. Length 1-1150th. to 1-480th.

E. *Zebra.* = *Epithemia Zebra* (Kütz.)—Striated, semi-lanceolate, oblong, with five transverse striæ in 1-1200th. The striæ are seen with difficulty except when the lorica is empty, or fossil. Length 1-1840th. to 1-570th. Found on fresh-water Algæ, and fossil at San Fiore, &c.

E. *granulata* = *Epithemia granulata* (Kütz.)—Striated, semi-lanceolate; elongate, slightly arcuate; surface granular, being minutely dotted in the interspaces of the moniliform striæ. Striæ five in 1-1200th. Length 1-240th to 1-140th. Fossil in Germany, United States. (P. 3. f. 165.)

E. *Faba* = *Epithemia Faba* (Kütz.)—Striated, semi-oval, in the form of a bean; slightly arcuate; apices obtuse, very little recurved. Striæ moniliform (dotted), nine in 1-1200th. Length 1-1150th to 1-570th. Fossil.

E. *diodon.*—Striated on the lateral surfaces, which are narrower than the plane central surface; apices obtuse, rounded and tapering; dorsum convex, obtusely bidentate, with two obtuse ridges at its centre. Length 1-570th. Fossil.

E. *triodon* differs from E. *diodon,* in having three dentations. Length 1-570th. Fossil. (P. 3. f. 164.)

E. *tetraodon.*—Large; dorsum very convex, and venter very concave; constricted near each end, which is rounded; dorsum with four large rounded elevations; striæ strongly marked. Length 1-570th. Living, Falaise; fossil in Finland.

E. *pentodon,* similar to E. *diodon.*—but dorsum with five ridges; ends attenuated, rounded. Fossil.

E. *Diadema.*—Six dentations, ends rounded. Fossil.

E. *serra.*—Large, lunate, dorsum sinuose, with twelve to thirteen indentations. Length 1-280th. Fossil in Sweden and North America.

E. *gibba* = *Navicula gibba* (Ehr.)—Striated, dilated at the middle, and gibbous, oblong; ends dilated and rounded; striæ nine in 1-1200th. Length 1-430th to 1-120th. Living, Gravesend; fossil, Isle of France. (P. 15. f. 27.)

Eunotia *Dianæ.*—Striated, linear, rather broader than deep altus); dorsum convex; venter concave; apices arcuate and slightly reflexed. Striæ thirteen in 1-1200th. Length 1-216th. Brandenberg.

E. *heptodon.*—Striated, short and semilunar; venter concave; dorsum convex, with seven obtuse dentations (teeth). (1-576th). In fossil meal, Sweden.

E. *octodon.*—Like preceding in form and size; eight dorsal dentations. (1-576th.)

E. *enneaodon.*—Striated, straight, or curved; venter plane or concave; dorsum with nine obtuse teeth. (1-432nd.)

E. *decaodon.*—Semilunar, venter concave, ten obtuse teeth. (1-480th.) Fossil in Sweden and North America.

E. *Hendecaodon.*—Curved, with eleven obtuse teeth. (1-450th.) Fossil.

E. *serrulata.*—Linear, curved; dorsum convex, thirteen obtuse teeth. (1-432nd.) North America.

E. *prionotus.*—Striated, almost straight and linear; fourteen dentations. (1-289th.) Sweden.

E. *bisoctonaria,*—Striated, linear, slightly curved; sixteen dorsal teeth. (1-280th.) Fossil.

E. *icosodon.*—Twenty teeth. (1-206th.) If more than twenty teeth, E. *polyodon.* Fossil.

E. *nodosa.*—Slightly arched; expanded at the centre on both sides; apices reflexed, obtuse. (1-240th.) Fossil, Barbadoes and North America.

E. *comta.*—Small, curved, rounded at each end; dorsum regularly convex; striæ strong and granular. Length 1-1152nd. In Greek marl.

E. *Hellenica.*—Long, somewhat curved, apices rounded; dorsum uniformly convex; very delicate striæ, intervening between the few but strong internal costæ. (1-480th) In Greek marl. Costæ four in 1-1200th.

E. *ocellata* = *Epithemia ocellata* (Kütz.)—Small, oblong, curved; ends rounded; back regularly convex; striæ strong and close, seven in 1-1200th. Length 1-1152nd. In Greek marl and in Peru. The three preceding species approach E. *Faba* in form.

E. *amphioxys.*—Narrowly linear, dorsums lightly convex, smooth;

venter slightly concave, minutely striated; ends suddenly contracted and produced; approaches E. *Dianæ*. (1-480th.)

EUNOTIA *Argus*.—Striated, dorsally oblong, regularly quadrangular, with a double row of pores (ocelli), approaching it to E. *ocellata*, which however is constricted towards each extremity. Cuba, Mexico. (P. 24. f. 11.)

E. *biceps*.—Striated, narrowly linear, curved, apices rounded; and a little revolute. North America and Falkland Islands.

E. *bidens*—Striated,; venter flat; dorsum convex, with a central furrow, rendering it bidentate; apices dilated, truncate. It resembles E. *diodon*, except in its truncate extremities. America.

E. *Camelus*.—Small, striated; dorsum with a double boss or hump; extremities produced, slender, obtuse. Cayenne and Labrador,

E. (?) *cingulata* = *Epithemia cingulata* (Kütz.)—Smooth, small, dorsum convex; margin of ventral surface tumid. It is divided by a longitudinal prominent band into two halves; approaches E. *gibberula*

E. *declivis*.—Wider, striated; venter flat; dorsum convex, with a moderate groove, making it bidendate; the dentations continuous with the acute apices by a straight descending line.

E. *depressa*.—Striated; narrowly linear, rectangular; venter plane or slightly concave; dorsima rather depressed, suddenly contracting towards the rounded apices. Length 1-108th. Fossil, Ireland, and in tropical America.

E. *dizyga*.—Striated (?) wider; venter concave; dorsum convex, with four dentations, approximating at the centre, Cayenne.

E. *Elephas*.—Striated, very broad curved, apices broadly rounded; back tridendate. Brazil.

E. *Formica*.—Striated, linear; turgid on each side of the centre, apices also enlarged. It = E. *nodosa*, with ends not reflected, but enlarged and straight Central and North America.

E. *gibberula* = *Epithemia gibberula*. (Kütz.)—With dotted striæ, small; dorsum widely expanded; apices constricted, recurved. Mexico, Connecticut.

E. *Librile* = *Epithemia Librile* (Kütz.)—Long and narrow, with dotted interspaces between the striæ; venter concave; dorsum at its

middle portion evenly convex, but decreasing suddenly towards the slightly revolute and obtuse ends. Mexico. (P. 15. f. 24, 25.)

Eunotia *monodon.*—Striated, elongate; venter concave; dorsum evenly convex; constricted slightly near the rather recurved ends. (P. 15. f. 27.)

E. *parallela.* —Linear, strongly striated, curved, apices simply rounded. North America.

E. *pileus.*—Small, striated, subquadrate, as seen on the sides; the under surface is wider than the upper; the latter slightly furrowed; ends obtuse, rather prolonged. Siberia. Fossil.

E. *longicornis.*—Large, elongated, dorsum continuously convex; extremities rather reflexed; venter concave; surface marked laterally by many wide costæ, alternating with more or less rounded or quadrate spaces, which are also striated. It is allied to E. *Argus.* (P. 24. figs. 6 to 9.)

E. *prærupta.*—Striated, elongate, back curved evenly and continuously to its dilated and truncated extremities.

E. *quarternaria.*—Small, narrowly linear, curved; back four-toothed; apices somewhat recurved. Liberia, Cayenne.

E. *quinaria.*—Small, narrow, linear; dorsum but slightly convex, with five dentations; ends rounded, Siberia, New York, Guano. (P. 15. f. 39.)

E. *Sella.*—Striated, dilated; dorsum, with a central groove, bidentate; continued as a regular curve to the acute ends. Cayenne.

E. *septena.*—Small, narrowly linear, with seven dorsal dentations. Labrador.

E. *Textricula* = *Epithemia Textricula* (Kütz.) Small, with parallel sides; back evenly convex; convexity prolonged to the round, not tapering extremities; striæ lateral, few and strong; their interspaces with fine longitudinal lines. Fossil, Iceland and Mexico.

E. *Tridentula.*—Small, narrowly linear, striated; dorsum tridentate. Fossil, Iceland, Cayenne, and Connecticut.

E. *centralis.*—Large, linear, striated, curved; venter turgid in the middle; dorsum even; apices enlarged, rounded. North America.

EUNOTIA *uncinata.*—Small, narrow, linear, curved; apices much constricted and capitate. North America.

E. *Zebrina* = *Epithemia Zebrina* (Kütz.)—Striated, elongate; dorsum evenly convex; the convexity extending gradually to the constricted but obtuse apices; interspaces of striæ dotted, "probably identical with E. *zebra*," Kützing. New York and Rhode Island.

E. *zygodon.*—Striated, linear, oblong; back with a furrow, rendering it bidentate, and its convex curve extending to the rounded apices. Guiana

E. *Cretæ.*—Of Caltanisetta, Sicily = *Cocconema Cretæ.*

E. *amphidicranon.*—Striated, oblong, straight, quadrangular; constricted on each side at the middle; extremities emarginate, furcate, (1-864th.) Fossil, Oregon.

E. *crocodilus.*—Elongate, striated, gently curved; back convex, depressed in centre; venter concave, gibbous at its middle; ends subacute, reflexed. (1-576th.)

E. *Luna.*—Striated, linear, with a lunate curve; dorsum evenly convex; venter concave, gibbous at its centre; ends simply obtuse. (1-372nd.) Fossil.

E. *Sima.*—Striated, linear, more gradually curved; dorsum rather convex; venter concave; ends obliquely subtruncate, and apices reflex. (1-456th.) Fossil.

The following new species were discovered by Ehrenberg, in earth from New Holland:—

E. *cœlata*, E. *Australis*, E. *cygnus*, E. *paradoxa.*

E. *senaria* and E. *nonaria.*—New species, discovered by Ehrenberg, in earth from Siberia.

E. *Alpina* (Kütz.)—Binate, primary side linear; rectangular on the other, dorsum convex, apices obtuse, truncate, transverse striæ very slender. (1-960th to 1-600th.) Bernese Oberland.

E. *monodon.* (Ralfs.)— Lateral view concave on one margin, convex on the other; constricted near the ends; striæ none or very obscure. Fresh water pools.

"The frustules are very minute, but vary greatly in length, being in some specimens only twice as long as broad, and in others six or seven times longer than broad. The front view has its ends slightly rounded, and its puncta very obscure. The absence of striæ may be

due to the minute size of the specimens under my notice, as I have occasionally observed very faint lateral striæ. A frustule of this species, though very much smaller, has a great resemblance to a solitary one of *Fragilaria pectinalis;* but in this plant the concavity of one margin is generally greater, and the constriction near the ends of the frustules more considerable; the front view, too, is narrower in proportion to the lateral; still it may eventually prove to be only the commencement of that plant."

This is probably identical with E. *monodon* of Ehrenberg..

Genus Eupodiscus.—Lorica simple, valves equal, orbicular, not concatenated; unilocular, furnished with tubular processes, perforated at the apex, projecting from near the margin.

The number of tubules was at first employed by Ehrenberg as a generic characteristic, but he now assigns to it but a specific value.

Eupodiscus is therefore equivalent to the previously-named genera, *Tripodiscus*, *Tetrapodiscus*, and *Pentapodiscus*.

E. *Germanicus*.—Has three tubular processes, and eighteen cells in 1-1200th. The lorica large, orbicular, and rather compressed; cells in radiating series; processes short and hyaline. Colour green. Cuxhaven. (P. 14, f. 41, 42.)

E. *quaternarius*.—Four appendages.

E. *quinarius*.—Five processes.

E. *monstruosus*.—Four processes on one side. Diameter 1-240th.

E. *Rogersii*.—Has six appendages round its periphery; valves with four-and-a-half large cells in 1-1200th., together with five radiating series of granules, ten in 1-1200th. Diameter 1-204th. Virginia.

E. *Baileyi*.—Seven processes around its circumference. Virginia.

E. *radiatus* (Bailey.)—In form, size, and reticulation, resembling the *Coscinodiscus radiatus* of Ehrenberg, but having four (or more) foot-like projections near the margin. A common form in the Southern States of America.

Genus Fragilaria.—Loricá simple, bivalve or multivalve, prismatic, having a general resemblance to *Navicula;* striated on the sides, leaving a central clear portion. In most species each extremity is furnished with two openings; these being in the same plane, the surfaces upon which the chain rests may be considered lateral, and the self-division will then be dorsal. The whole chain sometimes rises

in the water and turns upon itself; detached frustules have a progressive movement. The granular contents are green or yellowish when young, but reddish brown when old. The most evident manner of propagation is dorsal self-division. In many species growth continues both during and after self-division, but in F. *striatula* increase of size ceases after division.

In Hooker's British Flora, the characters thus stand.—"Frustula forming plane, pseudo-articulated, densely striated, fragile filaments, separating at the striæ (not cohering at their angles.) Named from their fragile character."

This genus gives name, and is the type of the family *Fragilariæ* of Kützing, which also includes the genera *Denticula, Odontidium,* and *Diatoma.*

Mr. Ralfs observes, (Ann. Nat. Hist., 1843.) "This genus is nearly allied to *Diatoma;* the chief distinction between them is, that in *Diatoma* the frustules cohere at the angles, and in *Fragilaria* do not. In one species of the latter this difference does not exist; it seems therefore an intermediate form."

"The puncta at the ends of the frustules, in this and other genera of the *Cymbelleæ,* I have never found any reason to believe to be openings, as many naturalists have supposed. Mr. Borrer informs me, that in *Fragilaria pectinalis* they are the terminations of slight grooves."

Besides multiplying by fission, described by Ehrenberg, the frustules of *Fragilaria* also conjugate and produce new forms.

The following strictures by Kützing, on some of the specific distinctions of Ehrenberg, employed in this genus, occur in a note to the description of *Fragilaria capucina* (Kütz.)

"It varies much in length and breadth, the single frustules as well as the bands. The contents also are subject to the same variations as those of other *Diatomeæ.* Nevertheless, Ehrenberg has made use of these variations in the institution of several species. P. 17, f. 1 is a tolerably common variety, which always appears in very long bands. These bands are often twisted, and, owing to this, appear smaller at some parts than at others, seeming to be broader when lying flat, and smaller when at an acute angle. The

shorter bands belong to Ehrenberg's *Fragilaria rhabdosoma;* p. 17, fig. 3 is F. *bipunctata;* figs. 4 and 12 is F. *diophthalma;* figs. 2 and 7 is F. *Scalaris;* figs. 5 and 8 is F. *multipunctata*; fig. 9 is F. *fissa;* whilst figs. 10, 11, and 6, represent the F. *tenuis* of Agardh."

Fragilaria *grandis.*—Striated, lanceolate; laterally, ends obtuse. As many as thirty frustules often cluster in a single band. (P. 3, f. 171.); striæ 11 in 1-1200th. Length of single rods or frustules 1-570th. to 1-120th.; *vide* F. *pectinalis* (Ralfs.)

F. *Glans.* = *Navicula (?) glans* (Ehr.)—Short, striated, expanded in the centre, so as to recal the figure of an acorn; ends constricted, obtuse. Striæ two to three in 1-1200th. Fossil. Length 1-1150th. to 1-570th.

F. *scalaris. The ladder-like Fragilaria.*—Smooth, seven to eight times longer than broad; granules of a fallow hue. Breadth of band (*i. e.* length of frustule) 1-860th. to 1-570th.

F. *diophthalma.*—Smooth, three to four times longer than broad; granules (ova, Ehr.) of a golden yellow colour, disposed in ten portions. Length 1-960th. to 1-1150th.

F. *pectinalis.*—Striated, two to six times longer than broad; dilated and lanceolate on the lateral surface; striæ eight in 1-1200th,; granules yellow. In the living state the striæ are very indistinct. (P. 3, group 176, a band, and the side view of a single frustule.) Common in ponds. Length 1-2200th. to 1-430th.

F. *rhabdosoma.*—Smooth, slender, and from five to twenty times longer than broad. The extremities of the unstriated lateral surfaces are needle-shaped. In some chains, the specimens are united together firmly; in others, the bands easily drop to pieces, the portions detached exhibiting locomotion, and may easily be mistaken for *Synedra* or *Navicula;* but the number and position of the openings are the distinguishing marks, (figs. 173, 174.) They are pale brown when recent, when dried greyish. Living in fresh water, fossil at Cassel. Length 1-570th. to 1-200th.

F. *turgidula.*—Striated, and from two to three times longer than broad, as seen in group 172; margin with many dentations; striæ six to nine in 1-1200th.; on secondary side lanceolate and rather obtuse. Length 1-720th. to 1-570th. Berlin.

Fragilaria *multipunctata.*—Smooth, slender, eight to sixteen times longer than broad; ova of a yellow golden colour, and multipartite. Found amongst Conferva, Length 1-570th. to 1-280th.

F. *bipunctata* is probably identical with F. *rhabdosoma*; it is smooth, and four to five times longer than broad. The granules are of a golden-yellow colour, and contracted into the form of two rounded spots. Found near Mount Sinai. Length 1-1200th to 1-760th.

F. *angusta.*—Smooth, and five to six times longer than broad. Length 1-480th. to 1-570th.

F. (?) *anceps.*—Small, linear; laterally is loosely striated; apices constricted, sub-capitate, obtuse; allied to *Gomphonema pupula.* North America.

F. *biceps.*—Small, linear, smooth; apices constricted, abruptly subacute.

F. (?) *binodis.* = *Navicular binodis.*—Quite smooth, small, narrow, panduriform (fiddle-shaped), constricted at the centre, and at each end; apices acuminate. Length 1-900th.

F. (?) *constricta.*—Linear, oblong, smooth; central constriction slight; apices suddenly acute. Falkland Islands and Mexico.

F. *Entomon.*—Linear, elongate, smooth, central constriction strong, apices rostrate.

F. (?) *glabra.*—Linear, smooth; apices slender, but obtuse. May be a variety of F. *biceps.* Guiana.

F. (?) *lævis.*—Resembles F. *amphiceros,* but destitute of the dotted striæ. Virginia.

F. (?) *Navicula.*—Oblong, smooth; dorsally four to five times longer than broad; central constriction very slight. Peru.

F. *pinnata.*—Testules three to six times longer than broad; linear, oblong, with strong striæ, fifteen in 1-1200th; apices simply rounded, allied to F. *Syriaca.* Mexico, Iceland.

F. (?) *striata.*—Oblong, turgid; striæ few but distinct. May be a variety of F. *pinnata.* Of the ten species just described, Ehrenberg makes the observation that he has not seen all of them concatenated, but often only single segments; consequently their genus is doubtful.

F. *leptoceros*—Laterally rhomboid, linear, elongate, ends attenu-

ated, straight, and acute; margin very finely striated; central space smooth. Diameter 1-432nd. Richmond, Virginia.

FRAGILARIA *Amphiceros.*—This species was described in 1843, by Ehrenberg, as a doubtful *Fragilaria,* and as equal to a *Cocconeis* deprived of its central foramen. His latest description is: Testule narrowly linear, rather turgid in the middle; apices much attenuated, but truncate; surface remarkable by its transverse striæ throughout. It differs from *Rhaphoneis* by the want of a median longitudinal band.

F. *Bacillum.*—Smooth, laterally linear, rounded at each end; five to six times longer than broad. Length 1-720th. Oran, Africa.

F. *striolata* (1844) = F. *pinnata.*

F. *nodulosa.*—Linear, twelve times longer than broad; striated transversely; striæ eighteen in 1-1200th; narrowly linear laterally, constricted below the apices, marked by narrow rows of nodules. Length 1-648th. Kurdistan. Transverse striæ (nodules) of the sides eighteen in 1-1152nd.

F. *birostris.*—Very small, suddenly attenuated at the acute extremities, laterally lanceolate. Has nearly the characters of a *Staurosira* (1-3120th.)

F. *granulata.*—Habit of F. *Amphiceros,* but stouter, tapering towards the ends; pinnules disposed in bundles, and granular. (1-720th.)

F. *pinnulata.*—Bacillar, equal throughout, often five to six times longer than broad; laterally rounded at each end, not attenuate; pinnules twenty-five in 1-1200th. (1-1152nd.)

F. *rotundata.*—Bacillar, equal throughout; length often nine times greater than breadth; laterally rounded, not contracted at the two extremities; twenty strong pinnules in 1-1200th. Length 1-480th.

F. *polyedra.*—Oblong, angular (hexangular?) bacillar; length three times greater than width; transverse striæ (pinnules) delicate. Length 1-900th. Fossil at Norwich. Connecticut. Allied to F. *Bacillum.*

F. (?) *mesotyla.*—Bacillar, turgid at the centre, ends obtuse, transversely striated, striæ granular. Length 1-480th. Very like *Stauroptera granulata,* but wants the longitudinal band and crucial umbilicus.

F. (?) *Stylus.*—Fossil, discovered by Ehrenberg in marl from Ægina.

Fragilaria (?) *Stylidium.*—Fossil, from the same locality.

F. *Seminulum* (Ehr.)—Fossil, in earth from Siberia.

F. *Syriaca.*—Testules eight times longer than broad, striæ wide apart, ten in 1-1200th. Length 1-960th. Marine, Syria.

F. *mesodon.*—Length not much greater than breadth (subquadrate), centre rather turgid on the lateral aspect, ends obtuse, constricted; four striæ, and teeth about the middle, only on the sides. Secondary side elliptic-lanceolate, dilated at the middle, with two to four striæ. Length 1-1104th. Friburg, in Switzerland, among Conferva.

F. *Catena.*—Smooth, length twice the breadth, ovate laterally. Length 1-1152nd. Mexico.

F. *acuta.*—Smooth, linear, length six times the breadth; laterally cuneate, acute. Length 1-576th. Among Conferva; Friburg, Switzerland.

F. *Capucina* (Kütz.)—Filaments more or less elongated, segments linear, rectangular; on secondary side acute and narrowly lanceolate. Common. This plant, according to Kützing, represents the species named by Ehrenberg, respectively, *Fragilaria rhabdosoma, multipunctata, bipunctata, angusta, scalaris, diophthalma,* and *fissa.*

F. *corrugata.*—Segments geminate, corrugated on each side; on secondary side acutely lanceolate. Length 1-1440th. Fresh water, Nordhausen.

Kützing adduces this species as synonymous with F. *conferroides* (Greville), thus described (Hooker's British Flora, vol. ii, p. 407.)—Filaments elongated, attenuated, compressed, excessively fragile, the joints about as long as they are broad (*i. e.* considering the breadth of the frustules to be that of the chain.) Streams. Tufted, two to four inches in length.

F. *hyemalis* (Ann. Nat. Hist., 1843, Lyngbye.)—Frustules broad, puncta at the ends very minute, lateral surfaces broad, elliptic-lanceolate, with well-marked striæ, which terminate in distinct puncta along the margins. Found in fresh-water pools and rivulets. Brownish when recent, whitish brown when dry; filaments elongated, attenuated, very fragile, separating into single frustules almost immediately after being gathered. Mature frustules generally two or three (occasionally five or six) times longer than broad.

In Hooker's British Flora, three other species, named, respectively,

F. *aurea*, F. *diatomoides*, and F. *striatula*, are described; but being all marine, contrary to the habitat of the true *Fragilaria*, probably belong to another genus, which Kützing supposes to be *Grammonema* (Agardh.)

Besides indicating F. *virescens* to be in part represented by F. *pectinalis* (E), Mr. Ralfs describes (Ann. Nat. Hist., vol. xii, 1843) a species under the latter appellation, but differing in characters from the similarly named one of Ehrenberg.

Fragilaria *pectinalis* (Ralfs.)—Frustules broad, with two evident puncta at each end; lateral surfaces striated, curved, constricted on one side near the end.

Var. (*b.*)—Found near Barmouth. F. *pectinalis* is brown when recent, but when dried is of a pale greyish-green colour, with a glass-like lustre. The endochrome is commonly contracted into two irregular lines, which are not unfrequently united at the centre; but often it is in four patches, apparently from the division of these lines. The frustules sometimes have a central pellucid spot, which does not appear to be connected with the endochrome. I have, several times, met with a remarkable state of this species, and have also received it from Mr. Jenner. Within the frustules, there is, apparently, another siliceous frustule, the lateral margins of which are rounded, having striæ like the outer frustules. In the longer frustules it is nearly elliptic; but, in the shorter ones, appears as if truncated at the ends, and, in both, it occupies the whole interior of the frustules, except the corners, where the puncta at the ends are situated; it is filled with a yellowish-green granular mass, mixed with numerous colourless vesicles.

The lateral surfaces (of F. *pectinalis*) are very characteristic; one margin is flat, or slightly concave, the other convex, and slopes off rather abruptly near the ends, where also it is slightly constricted. Besides these constrictions, indications of two others may often be observed on the convex margin; but, in a specimen sent me by Mr. Slaney, these are so strongly marked, that if I had not seen intermediate forms, I should have supposed it a distinct species. I have made it var. (*b*)—F. *undulata*, which perfectly agrees with the usual state of the species, except in the lateral view, the convex margin of which has two indentations, giving it an undulated appearance; the

other margin is flat, with a projection in the centre. In both forms the lateral surfaces are marked with close transverse striæ. Mr. Ralfs appears to regard fig. 171, as representing this variety.

Fragilaria *virescens* (Ralfs.)—Frustules broad, with two evident puncta at each end; lateral surfaces turgid, lanceolate, constricted near the ends; striæ none, or indistinct. Fresh water pools. Plant green, not much altered in drying. The frustules frequently separate and cohere by the angles in a zig-zag chain, from which circumstance it is doubtful whether the plant is rightly placed in this genus. The frustules are often nearly square, but more frequently three to four, or sometimes five to six, times longer than broad. The endochrome is greenish, and consists of numerous small granules, either scattered or collected together in the centre of the frustules.

When the frustules adhere together by their angles, this plant bears a considerable resemblance to young specimens of *Diatoma vulgare*, from which, however, it may be distinguished by its green colour when recent, by the form of the lateral surfaces, and by the apparent absence of striæ under a moderate power of the microscope.

Mr. Ralfs considers this species = F. *pectinalis* (E.); Kützing thinks it = F. *confervoides* of Greville; but the former says it is not, for F. *confervoides* (Grev.) he has ascertained to be F. *hyemalis*.

Genus Gallionella (Ehr.) = *Melosira* (Agardh.)—Lorica bivalve, cylindrical, globular, or discoid, concatenated, chain free. The segments (frustules) have each one or two oblique furrows, with several openings in them. The lorica, viewed end ways, is circular, resembling a coin. It is fragile and incombustible; that of G. *ferruginea* (see description of this species and remarks) appears to be composed of silicate of iron. A coloured and divided mass of granules (ova, E.), clustered like grapes, is seen internally, as also colourless vesicles. Change of place has not been seen. In their concatenated form, they closely resemble filamentous Algæ. Nearly all the species are found both fossil and living; the fossil forms, especially, are exquisite objects for the microscope, under a high power and proper illumination. Living forms occur both in fresh and in salt water.

Kützing's definition differs from that of Ehrenberg, mainly in describing the filaments as adnate, or attached. Like Mr. Ralfs, the

first-named naturalist makes two sections of this genus, according as the segments are globular or elliptic, and keeled (The term keeled, *carinatus,* is applied by Kützing to the opposite sides of each segment, which appear produced beyond the first or chief circle, or cut off by a segment of another circle from it), or cylindrical and not keeled; calling the first *Lysigonium,* the second *Gallionella.* "This genus," says Mr. Ralfs (Ann. Nat. Hist., vol. xii, p. 347), "in its cylindrical filaments, differs from the other *Cymbellæ,* and thus connects them with the Confervæ; but it agrees with them in being generally of a brown or yellowish colour when recent, and especially in its siliceous filaments, and in the presence of striæ; characters which sufficiently point out the propriety of its present situation among the *Diatomeæ.* The filaments have no proper margins marked by distinct characters, as in the other genera of *Cymbelleæ* (Diatomeæ); and the striæ, when present on the junction-surfaces, are not transverse, but radiated.

"In the first section of this genus, the species belonging to which are generally marine, the ends of the frustules are convex, and as there are no distinct junction-surfaces, a moniliform appearance is produced. The central line is more strongly marked in this than in the other section, and seems to divide the frustules into two equal portions. It becomes broader, and at length double, and, ultimately, an intermediate growth separates the two halves of the frustule, which, during this process, do not increase in size; but when the intermediate space is equal to the diameter of the original frustule, two new frustules are formed, by the addition of two hemispheres on the inner sides of the separated portions. The outer siliceous covering still remaining, the frustules are connected in pairs, and appear like two globules within a joint, as they are characterized by Harvey in G. *nummuloides,* and by Carmichael in G. *globifera.* The above description belongs more particularly to G. *nummuloides,* but the process in the other species, in the first section, is the same; a series of changes, nearly similar, occurs in *Isthmia.*

"All the species in the second section are found in fresh water. The frustules are not united in pairs; their junction-surfaces are distinct, and nearly flat, and their central lines are probably furrows; hence, whatever parts of these lines occupy the margin of the field

of view, as the filaments are turned round, they all appear like puncta.

"* Filaments moniliform, frustules united in pairs. Species G. *nummuloides*, G. *Borreri*, and G. *globifera*.

"** Filaments not moniliform, frustules cylindrical. Species G. *arenaria*, G. *varians*, and G. *aurichalcea*.

"*** Filaments very slender, joints obscure. Species G. *ochracea*."

Mr. Thwaites has proposed (Ann. Nat. Hist., 1848) another arrangement of *Melosira*—subdividing it indeed into three genera—viz., *Aulacoseira*, *Orthoseira*, and *Melosira*. This subdivision he would base on differences observable both in the character and position of the sporangia, and in the form and structure of the frustules themselves.

The genus *Melosira* (says Mr. Thwaites) as it stands, after this removal of some of its species, will include all those whose frustules are in any degree convex at their extremities, and have the central line indicating the place of future fissiparous division. It will probably be found expedient to separate *Melosira arenaria* (Moore, see page 376), from its present congeners, when its sporangia have been discovered.

Besides multiplying by fission, the *Melosira Gallionella* (Ehr.), develope new frustules by the formation of sporangia; and, although these sporangia are *not* the result of an *evident* conjugation, or mixture of endochromes of two frustules, as witnessed in many of the *Diatomeæ*, yet Mr. Thwaites concludes, that the difference in the phenomena, though structural, is not physiological. In this genus, a change takes place in the endochrome of a single frustule—that is, a disturbance of its previous arrangement, a moving towards the centre of the frustules, and a rapid increase in its quantity; subsequently to this it becomes a sporangium, and out of this are developed sporangial frustules as in other *Diatomeæ*.

In the system of Kützing, this genus gives name to the family *Melosireæ*, which comprise the genera *Cyclotella*, *Pyxidicula*, *Pododiscus*, *Podosira*, and *Melosira*.

The same observer states that *Melosira* is attached by a soft, gelatinous pedicle, proceeding from the middle aperture of the ventral surface, a characteristic of this genus.

GALLIONELLA *lineata.*—Cylindrical, the ends connecting them together (the *junction surfaces*) compressed (fig. 128.) The lines on the surface of the segments are transverse, relative to their longer diameter; the endochrome yellow or green. A single chain consists sometimes of 1200 to 4000 segments, forming a chain two to three inches in length; length of frustule 1-1400th to 1-430th. Marine

The *Melosira lineata* (Kütz.)—Adduced as synonymous with *Gallionella lineata* (E.) is described as having *smooth* segments conjoined in pairs; and, in the illustrative figure, no lines, save some few very delicate ones in the central portion of each frustule, are exhibited, like those in Ehrenberg's drawing.

G. *nummuloides* (E.)—Resembles the preceding species; but each frustule has its ends convex, and near each of them a line, less strongly marked than the central one. The convex ends render the segments almost globular; the latter, also, are smooth; their contents yellowish-green when dry, but brown when recent. Diameter 1-1700th to 1-860th. Sea or brackish water. (P. 14. f. 14, and wood cuts.)

G. *varians* = *Melosira varians* (Ralfs.)—Joints cylindrical, with flat ends; when separate, they rest upon their ends and appear like coins; and in such a position, with a high power, delicate radiating striæ may be seen (as in fig. 131.*) Contents yellow or greenish. Size 1-2200th to 1-480th. Fossil and living; the former constitute the principal part of the earthy deposits of white powder used in polishing silver plate.

G. *distans.*—Segments smooth, short, cylindrical, plane and truncate on the junction surfaces; with two sulci or furrows, separated by a more or less considerable interval (distant.) Segments closely conjoined; their two diameters equal, or that in the length of the chain double the other. Diameter 1-3456th to 1-864th.

G. *sulcata.*—Segments short, cylindrical, about equal in their two diameters; transversely striped near each junction-surface, leaving a clear central interspace; surface of end view, with lines radiating

from a clear central spot, and extending to the marginal zone. (P. 3, f. 131, and P. 14, f. 26.) Diameter 1-860th to 1-600th.

Gallionella *moniliformis*.—Smooth, large, cylindrical, short; ends truncated cones; when single, and viewed from the back, they appear octagonal; contents greenish. In sea water; often confounded with G. *lineata*. Size 1-860th.

G. *aurichalcea*. — Segments cylindrical and slender; their length full twice the diameter, with either a single or two perforated rays contiguous at the middle; the ova are green, but, when dried, become of a golden-yellow colour. Thickness 1-2300th to 1-1720th. In fresh water, ditches, and slow streams.

G. *ferruginea* = *Melosira ochracea* (Ralfs.) — Slender, oval, convex at both ends; smooth. In many, perhaps in all chalybeate waters, and also in peat water, which contains a small proportion of iron, this is to be found; it is of the colour of iron-rust, and in mineral springs, in which it abounds, is often taken for precipitated oxide of iron. It covers every thing under water, but forms so delicate and floccose a mass, that the least motion dissipates it. In the spring of the year, this mass is composed of very delicate pale yellow globules, which can be easily separated from each other. They unite together in rows, like short chains, and produce an irregular gelatinous felt or floccose substance. About summer, or in autumn, they become developed into more evidently articulated and stiff threads, of a somewhat larger diameter, but still form a complicated mass or web, and, either from adhering to each other or to delicate conferva, appear branched. In the young condition, when examined under shallow magnifiers, they resemble gelatine; but with a power of 300 diameters, the flexible granules are discoverable, and with dexterous management, the little chains forming the felt or floccose web can be made out. In summer, on the other hand, its structure can be observed much more easily and distinctly. Early in spring, the colour is that of a pale yellow ochre; but in summer, that of an intense rusty red, (P. 2, f. 129 and 130.) Diameter 1-1200th

According to Kützing, this is not a species of *Gallionella*, but a *Conferva*; it has no true siliceous lorica, as have true *Diatomeæ*, and the coating of oxide of iron is not an essential element, but

merely an incrustation, such as will form on well-known *Conferva*, placed under like circumstances, *i. e.* in water holding salts of iron in solution, which are subsequently precipitated by exposure to the air, and converted into the red oxide.

The same author differs from Ehrenberg, as to the part played by the so-called *Gallionella ferruginea* in the production of the oxide of iron in chalybeate waters, of bog-iron ore, of clay-iron ochre, &c. For he observes, in many springs rich in iron, no such organism is found, although other Conferva may be present, Conferva, however, not peculiar to such habitats, but common in springs and ponds generally.

Mr. Ralfs (Op. Cit. p. 352), however, in part supports Ehrenberg, declaring, that though identical with *Conferva ochracea* (Dillwyn) yet "Ehrenberg is no doubt correct, in placing the plant in this genus, as the filaments are siliceous and cylindrical."

Gallionella *undulata* = G. *varians* (Hesse.)—Joints large, often wider than deep, surface smooth; the wall of the testules flexuose beneath the integuments; joints on the side, very finely radiate. Diameter 1-576th.

G. *coarctata.*—Joints smooth; its habit is that of G. *varians*, but it is devoid of the striæ on the sides. (P. 14, f. 20 and 27.)

G. *granulata.*—The entire surface covered by dotted transverse lines; when concatenated, these lines are longitudinal with reference to the entire chain; dotted longitudinal lines in the joints (transverse in the chain) characterize G. *marchica*,

G. *lirata.*—Has the habit of G. *granulata*, but with stronger lines, disposed like the strings of a lyre. United States.

G. *oculus.*—Habit of G. *sol*, but larger with equal and stronger rays, sixty-seven in number, in the circuit of the very smooth disc. Diameter 1-240th. Southern Ocean.

G. *pileata.*—Joints wider than deep, surface smooth; the two sutures of the valves much separated, very minutely dotted; lateral disc convex, smooth, often narrower than the connecting band (cingulum) or medium-body, hence the hat-like form. Diameter 1-648th. Southern Ocean.

G. *Sol.*—Joints narrow, mostly five times deeper than broad, nummiform; disc level, large, smooth; margin strongly and broadly

rayed, with eighty-four rays; suture of the valves single. Diameter 1-336th.

GALLIONELLA *Tympanum.*—Disc broad; centre smooth; slender margin, minutely striate. Diameter 1-276th. Southern Ocean,

G. *sculpta.*—Joints large, depth exceeding breadth; lateral surface, with transverse, dotted lines, (which, when the segments are conjoined, become, in relation to the entire chain, longitudinal,) densely striated, and elegantly sculptured; two sutures about the middle, with a narrow interspace. Diameter 1-960th. Fossil, Oregon.

G. (?) *spiralis.*—Joints small, oblique; breadth greater than depth, or equal; surface with loose, transverse, dotted lines; chains forming curves and spirals. Diameter 1-2304th. Fossil, Oregon.

G. *calligera.*—Joints small, smooth, with .the habit of G. *distans;* breadth double the depth; median suture single; a double granular mass enclosed within, like G. *undulata.* Diameter 1-1728th. Fossil in pumice, Island of Ascension.

G. (?) *coronata.*—Testules with the habit of G. *sulcata;* the outside of the cylinder striated; margin of disc crenate; disc smooth, slightly convex, with a circlet of granules at its centre like a crown of pearls. Diameter 1-864th. Fossil, sea coast of Patagonia.

G. (?) *plana.*—Testule with the habit of G. *sulcata,* but with the disc of the valves plane, smooth, not radiated nor granular. Diameter 1-1152nd. This form may possibly be but G. *sulcata,* with its markings destroyed (worn smooth) by igneous action. Also fossil, Patagonia, in pumice,

The following species have been found fossil:—

G. *Novæ Hollandiæ,* G. *procera,* G. *tenerimma,* G. *punctata,* G. *gibba,* G. *Horologium,* G. *lineolata,* G. *asperula,* G. *biseriata,* G. *punctiger,* and G. *crenulata* = *Melosira crenulata.* See plate 14, f. 29.

Melosira of Kützing, and *Aulacoseira* and *Orthoseira* of Mr. Thwaites, are here introduced as sub-genera, from their alliance to *Gallionella.*

Sub-genus MELOSIRA.—The following species are derived from the valuable papers of Mr. Ralfs, in the *Annals of Natural History,*

"M. *globifera* (Hervey.)—Frustules (testules, Ehr.) nearly globular, with numerous striæ, which are most evident on the siliceous covering. Filaments affixed by a short stipes (pedicle;)

frustules in pairs, each with a strongly-marked central line (suture.) On marine Algæ, Torquay, Hastings, &c.

"MELOSIRA *Borreri* (Greville.)—Frustules rather longer than broad, cylindrical, rounded at the ends, with a central strongly-marked line (suture of the valves, Ehr.) Marine Algæ."

This species much resembles M. *nummuloides;* the filaments are stouter, the ends less convex, and marked only with a central line.

"M. *arenaria* (Moore.)—Filaments stout, frustules broader than long, with a single central line; junction-surfaces closely united, striated. Fresh water; brownish when recent; pale green when dried.

"Filaments much stouter than in any other species, distinct to the naked eye; when rubbed between the fingers, feeling rough like grains of sand, whence its specific name. The junction of the frustules appears like a dentated surface. (See f. 131 and 199.) The characters by which this species is distinguished from M. *varians* have been so clearly pointed out by Mr. Dalrymples, that I shall use an extract from his letter, instead of making any observations of my own."

"*Melosira varians* (Agardh) is as clearly *Gallionella varians,* as *Melosira arenaria* (Moore) is *Gallionella varians,* (Ehr.)—Still no tyro in Natural History could presume, that the two were the same species. The characteristic difference exists in the well-marked feature of the striæ at the junction-line of the corpuscles, and which, combined with their discoid form, bears a strong resemblance to the milled heads of many of the adjusting screws of our microscopes. Added to this, is the appearance of radiating lines, seen when the flat surface of the disc is in view."

M. *varians* (Ralfs.)—Frustules once-and-a-half to twice as long as broad, with a single central line; the ends slightly rounded; junction-surfaces *without* striæ; filaments very slender, but varying much in thickness; fragile. Brownish when recent; becomes green on drying. In fresh water rivulets, and ditches.

The end being rounded, the joints are not so closely united as in M. *arenaria* and M. *aurichalcea.* Not unfrequently, this species has the joints dilated here and there into a globular form; and in this state the central furrow gives the appearance of two joints combining in the formation of the inflated cells (P. 24, f. 32.)

Melosira *aurichalcea* (Kütz,)—Filaments more slender, and more uniform in size; joints larger, and more closely united: it especially differs in having two central lines, and striated junction-surfaces, and in not turning green in drying.

Nägeli describes and figures a species which he refers to the genus *Gallionella;* but it is a doubtful member. His description, however, especially that of the self-division, induces us to give it nearly in his own words, with his name, (Ray Society, 1848, p. 219.)

Gallionella (?) (Nägeli.)—Figure shortly cylindrical. Diameter .014th to .027th of a line.

Both the terminal surfaces of the cylinder are flattened, so that, when seen sideways, it appears rectangular, with the angles rounded off. It is composed of one simple cell, whose membrane is covered by a siliceous plate, and its cavity contains chlorophyll granules, which lie upon the membrane in two circular bands. (P. 24, f. 26 to 28.) Each of these bands occupies one of the two obtuse angles of the cylinder, and appears annular from above rectilinear, from the side (See description of Plate 24.)

In developing, the relative length of the cylinder increasing, a septima divides it into halves, (P. 24, f. 28c) which, when complete, the latter separate as two distinct beings. The nascent chlorophyll-granules are either spread equally over the surface, or more frequently arranged in radii from the nucleus in the centre; they lie in the course of the currents streaming from the nucleus. Compared with a cell of Conferva, or of Spirogyra, all three agree in the forming of a septum, in the similarity of their contents, and in the depositions of extra-cellular substance. But Gallionella differs from both, by the production of an individual from every cell; also, by the chlorophyll forming two lateral bands, and the siliceous extra-cellular substance an intermediate one.

"So far as my investigations go, *Gallionella*, which, according to Ehrenberg, posseses a bivalved or multivalved shield, agrees with the above-described plant in all essential particulars. The lines, for instance, which would intimate a division of the shell into two or more pieces, are the septa by which the cell-division is effected. As in the filiform Algæ, these walls at first appear as delicate lines; then, by an increase of thickness, seem two clearly defined lines, and

at last present themselves as two lamellæ, separated by an intermediate third line. The perforations which Ehrenberg described, I look upon as nothing more than inter-cellular spaces, formed between the two new-formed cells and the parent cell. These so-called perforations are only visible, therefore, on the two lateral borders where the wall abuts upon the membrane. The Confervoid Algæ exhibit a similar appearance."

Under the name *Melosira*, Kützing describes the following additional species or varieties of *Gallionella*.

MELOSIRA *nummuloides*.—Large, segments with very finely dotted valves, (when dried of a golden colour); with evident keels (carinæ.) Diameter 1-840th. Baltic, North Sea, and Coast of North America.

The name of this species would suggest its identity with *Gallionella nummuloides* (Ehr.), but Kützing finds the synonyme of the latter in his *Melosira salina*, between which and the *Melosira* just described, he indicates a specific distinction.

M. *dubia*.—Small; joints compressed spheroids, smooth. Diameter 1-1200th.

M. *subflexilis*.—Of middle size; joints cylindrical, quite smooth; the younger ones elongated; the adult shortened, depressed, conjoined in pairs; secondary sides rather convex; connecting isthmus of the conjoined segments short. Diameter 1-564th. Friburg.

M. *tenuis*.—Very slender; joints cylindrical, quite smooth; long diameter one-and-a-half to two times greater; closely connate; no sulci. Diameter 1-5760th. Fossil in the polishing powder of Luneberg.

M. *Jurgensii*.—Slender; joints quite smooth, elongate, with two slight contractions beneath the siliceous epidermis; at junction surfaces convex, hemispherical, closely concatenate. Diameter 1-1800th. to 1-1200th.

M. *Hetrurica*.—Small, joints cylindrical, depth double the width; margin of junction surfaces finely denticulate; lateral surface with dotted rays. Diameter 1-3600th. to 1-1800th. Fossil, San Fiore.

M. *Italica*.—Small, joints cylindrical, quite smooth; long diameter (depth) double the transverse (width); on secondary sides convex. In the mountain meal of San Fiore.

MELOSIRA *crenulata*.—Similar generally to the last, of which it is little more than a variety; but the long diameter of its segments is two to four times greater, and the margin clearly denticulate. Diameter 1-1440th. England, North and South America. (P. 14, f. 29.)

M. *Binderana*.—Another variety; more slender; joints variable, sometimes ventricose; length four to eight times the greater; junction-margin minutely striated. Diameter 1-6000th. to 1-2400th. Hamburg.

M. *Americana*.—Size moderate; all the segments united in a cylindrical tube, separated only by septa; transversely striated on the margin, and divided by a median sulcus. Diameter 1-660th. Tropical, America,

M. *decussata*.—Slender, joints cylindrical, the two diameters nearly equal; remarkable in being spirally decussated by numerous very finely dotted lines. Shores of the Elbe.

Sub-Genus AULACOSEIRA (Thwaites), (Ann. Nat. Hist. 1848.)—Cells cylindrical, bisulcate, extremities more or less orbicular, concatenated in filaments.

Aulacoseira differs from *Melosira* by the deficiency of the central line, the place of future fissiparous division. Each of its frustules too, have two somewhat distinct sulci or fossulæ (furrows, Ralfs) passing round it. The absence of the central line separates *Aulacoseira* also from *Orthoseira*, from which it is further distinguished by the convex ends of its cells or frustules.

Its typical species is the *Melosira crenulata* (Kütz.) the M. *aurichalcea* (Ralfs); A. *crenulata* (Thwaites.) Characters those of the genus. Sporangium spherical, with its axis of elongation at right angles to that of the frustule from which it originated. Around the young Sporangium a considerable quantity of mucus is developed, by which the empty half-frustules are for some time held attached. (P. 24, fig. 33,) represents filaments of *Aulacoseira crenulata* with Sporangia.

Sub-genus ORTHOSEIRA (Thwaites.) — Cells exactly cylindrical, with a central line, connected in cylindrical filaments; internal cavities spherical or sub-spherical.

Typical species, *Melosira Americana* (Kütz.), in Mr. Thwaites arrangement, *Orthoseira Americana*, differing from the following new species principally in the ends of its frustules being striated.

ORTHOSEIRA *Dickieii.* — Filaments short; cells quite smooth; other characters those of the genus; sporangia fusiform. (P. 24, f. 29a.)

"The filaments of this beautiful species consists generally each of from two to four frustules, which are hyaline and perfectly smooth; central cavity filled with dark red-brown endochrome; Sporangium fusiform, marked with numerous annular constrictions, whose formation is progressive, and which go on increasing until the sporangium is fully developed (P. 24, f. 296, a filament, the terminal cells of which have each commenced to develope a Sporangium; and fig. 29c, a mature Sporangium.) This formation thus occurs: at the commencement of the formation of a Sporangium, the endochiome, at the same time that it withdraws from the end of the frustule, produced at its centre an additional ring of cell-membrane; and this process continuing to take place at certain intervals, each new ring of cell-membrane exceeding in diameter those previously formed, produces at length the structure represented in fig. 29c; or it may be a more correct explanation of the process to say, that an entire new cell-membrane has been developed by the young Sporangium at the time each new ring has been formed, and that, thus have originated the several chambers into which the ends of the Sporangium are divided; fissiparous division subsequently takes place, and sporangial frustules are developed from each half, as shown in fig. 29d. This species was found by Dr. Dichie, in a dark dripping cave close by the sea, near Aberdeen, and covering the mosses, Hepaticæ, as a fine blackish green sand. (Ann. Nat. Hist. 1848.)

Genus GONIOTHECIUM (Ehr.)—Lorica round, not in chains, having a central constriction or furrow, each end abruptly attenuate and truncate, so as to assume an angular figure.

This genus resembles *Pyxidicula*, but has a central constriction and truncate ends. Fossil.

G. *Rogersii.*—Testules in pairs, (binate), smooth; each dorsally sub-quadrate, angular with three verticilli; laterally, elliptic oblong,

with two to three median circles; the two testules connected by a very wide central band, and by their apices; the opening (hiatus) on each side the band large, and sub-orbicular. Diameter 1-588th. Virginia Named after Dr. Rogers, the discoverer.

GONIOTHECIUM (?) *didymum.* — Testules binate, smooth, transversely oblong, obtuse; emarginate at the centre on one side; on the other with two tubercles. Diameter 1-1200th. Virginia.

G. *Gastridium.*—Testules binate, smooth, transversely oblong, truncate at each end, abrubtly dilated at the middle of the ventral surface, but not contiguous. Diameter 1-960th Virginia.

G. *hispidum.*—Testules binate; each semi-lunar and hispid, with a tuberosity (umbo) on the inner side at the centre; the halves contiguous. Diameter 1-1728th. Virginia.

G. *monodon.*—Binate, smooth; each half linear-oblong, truncate at each end; outer side uniformly straight, the internal with a median tuberosity, not contiguous.

G. (?) *Navicula.*—Smooth, small, binate, oblong, and rather turgid, truncate at each end. I have not yet observed a median connecting tuberosity. Length 1-1680th. Virginia.

G. *obsusum.*—Binate, smooth; each testule transversely oblong, obtusely tri-lobed; no connecting band. Diameter 1-696th. Virginia.

G. *Odontella.*—Binate, smooth; each testule transversely oblong; dorsally semilunar or gently angular; laterally oblong, navicular, with three concentric circles; the halves conjoined by the central band and by their apices; the aperture on each side oblong, contracted at the middle. Diameter 1-480th. to 1-276th. Virginia.

G. *crenatum.*—Specific characters unknown. (P. 24, fig. 10, represents apparently a semi-frustule.)

Genus GRAMMATOPHORA (Ehr.)—Lorica bivalved, prismatic; self-division imperfect; the cluster curved; joints gaping at one of the angles. Within are two septa, dividing the body into three longitudinal portions. Marine.

The form of this genus recals that of *Tabellaria,* with two internal siliceous folds (septa or vittæ) which are remarkable in being curved after the manner of letters.

Kützing's description is rather different from the foregoing; " *Bacilli* oblong, tubular, adnate, ultimately connected only by a narrow link (isthmus); with two constant longitudinal *vittæ*, interrupted in the middle, and more or less curved." It is a member of his family *Tabellarieæ;* tribe *Vittatæ.*

GRAMMATOPHORA *Africana.* = *Navicula Africana,* (Ehr.)—Dorsally square or oblong; laterally navicular and obtuse. Internal folds three in each half and undulated. Fossil in the chalk marl of Oran; alive in sea water, at Tjörn. The contents are brownish, or golden-yellow-coloured, filling the whole of the interior, and only leaving a bright transverse band just where the transverse line crosses. Length 1-2300th. to 1-480th.

G. *angulosa.*—Viewed dorsally, square or oblong; on the side, navicular and obtuse; internal fold having many acute angles, (plicate); this species may be only a variety of the preceding It is colourless. Fossil in the chalk marl of Oran. Length, fossil 1-910th.; living, 1-1150th.

G. *Mexicana.*—Viewed dorsally, quadrangular; on the side, linear, obtuse, the rounded ends being suddenly constricted. Internal folds straight in the middle, uncinate at the extremity. Isthmi tumid. Alive in sea water, at Vera Cruz, Naples, and Gaeta. Length 1-960th., little more than twice the breadth.

G. *oceanica.*—Dorsally quadrangular; on the side, navicular or linear, obtuse; ends gradually attenuated; internal folds straight in the middle, uncinate towards the ends; isthmi slender; ossil in the chalk marl of Oran; alive in the Cattegat, &c. This creature forms long zig-zag bands, which are fixed by mucus to Algæ and Sertulariæ. Dr. Ehrenberg saw some frustules fourteen times longer than broad, and others nearly square; granular contents yellow or reddish-brown. Length, fossil 1-720th.; living, 1-2300th. to 1-360th. (P. 14, f. 52, 53.)

G. *undulata.*—Dorsally quadrangular; laterally linear, with several undulations; internal folds undulated. Colourless. Alive, Vera Cruz. Fossil, Greek marl. Length 1-860th. Breadth a third to one-half.

G. *gibba.* — Quadrangular dorsally; striated transversely on

each side, and tumid at the middle, with straight internal folds inflected only at the apex. Apices rounded. (P. 14, f. 48. 49.) Cuba.

Grammatophora *Islandica.* — Quadrate or oblong dorsally; navicular laterally, and striated; with three internal folds, curved at the centre. Iceland.

G. *stricta.*—Large, quadrate dorsally, or oblong; on the sides, navicular, lanceolate, and smooth; internal bands straight, not inflected at the apex. Vera Cruz and North America

G. *Mediterranea.*—Oblong dorsally; laterally navicular and obtuse, striated; internal folds four to five, undulating. Length 1-480th.; on French Coast at Cette; closely allied to G. *Islandica.*

G. *serpentina.*—Narrow, linear, smooth, six to seven times longer than broad; with seven internal undulated folds. Length 1-252nd. Southern Ocean.

G. *marina* (Kütz.)—Smooth, capitate at one end, vittæ (internal folds, Ehr.) with one fold turned outward (extrorse); on secondary side (laterally) linear, apices tapering by degrees, obtuse. Length 1-1080th. to 1-420th. The portions connecting the angles (isthmi) of the several frustules, slender. In Atlantic and Pacific Oceans. Kützing represents this as = *Bacillaria Cleopatra* and *Grammatophora oceanica* (Ehr,)

G. *tropica.*—Large; margin striated; in one aspect, linear with rounded ends; vittæ with one outward fold; isthmus tumid. Length 1-600th. to 1-156th. On marine Algæ, Cape of Good Hope.

G. *hamulifera.*—Small, smooth; vittæ at each extremity, hooked (uncinate.) Length 1-2400th. to 1-960th. On marine Algæ, Chili and New Holland. (P. 16, f. 22.)

G. *gibberula.*—Margin transversely striated; vittæ with one fold near the apex, laterally lanceolate, somewhat tumid near the middle, ends obtuse, isthmi slender. Length 1-450th. This not improbably = G. *mediterranea* (Ehr.) Bay of Naples.

G. *Anguina.*—Large, smooth, vittæ with flexuose folds, at their inner extremity, hooked. Length 1-650th. to 1-360th. Among Algæ. Jamaica,

Genus Grammonema.—(Agardh.)—Filaments gelatinous, elongated,

flexible, not fragile; frustules (testules, Ehr.) rectangular, plane, not striated, scarcely siliceous.

In appearance, this genus comes very near to *Fragilaria*, with which it is united by most writers, but its habit is so very different, that I am inclined, with Agardh, to keep them distinct. In *Fragilaria* the filaments are very fragile; the species do not adhere well to paper; the frustules are siliceous and glass-like, and may be subjected to a red heat, without any other alteration than the destruction of the colouring matter; and at each end are two, more or less distinct, pellucid puncta.

In *Grammonema* there is scarcely any silica, in which important character it differs from most of the *Diatomeæ*, the filaments are not fragile, but highly mucous, adhering firmly to paper or glass, and, when dried, appearing like a mere stain; the application of nitric acid, or of a red heat, destroys their form, and I can perceive no puncta at the end of the frustules. The filaments are elongated, ribbon-like, and composed of numerous frustules, which are longer than broad. (Ralfs in Ann. Nat. Hist., vol. 13, 1844, p. 457.)

Grammonema *Jurgensii* = *Fragilaria aurea* (Hooker).—Filaments attenuated, yellowish-brown; frustules three to eight times longer than broad; slightly separated at the angles (P. 24, f. 24, 25.)

Var. *(b) Diatomoides.*—Filaments green when dried, and elongated, giving a feathery appearance to the plants to which they are attached, very mucous, flexible, gradually attenuated; frustules under the microscope nearly colourless; slightly attenuated at both ends, and hence disconnected at their angles; and as the ends are often also somewhat rounded, the margins of the filaments have a crenate appearance. In a mass, both varieties are dark brown, but much paler if separated in the water. In the first variety the colour is but little altered in drying.

Genus Halionyx.—Lorica bivalve, orbicular, not concatenated; surface of disc rayed; number of rays definite, not starting from the umbilicus; no internal septa.

It resembles *Actinocyclus*, except in its umbilicus not being radiate, or, in other words, the central ocellus is wanting. In like manner, *Coscinodiscus* differs from *Symbolophora* in its non-radiant umbilicus, which is a simple void space.

HALIONYX *senarius.*—Surface of testules with six rays, their intervals occupied by parallel lines; transversely and loosely cellular, umbilicus entire, dotted. Diameter 1-720th. Southern Ocean; approaches *Actinocyclus biternarius.*

H. *duodenarius.*—Rays twelve; umbilicus large, with no dotted rays. Diameter 1-576th.

Genus HELIOPELTA, (Ehr.)—Lorica of two equal valves, orbicular, not concatenated (?); divided internally into cells by imperfect radiating septa, which alternate with a series of external depressions; centre smooth, angular, with large marginal apertures, equal in number to the rays; and with closely-set, erect spines, beneath the margin, on each side. The surface of the valves appears as if overspread with a fine granular membrane, or veil.

Has the habit of *Actinoptychus,* but differs, like *Denticella,* from *Biddulphia,* by the lateral spines of the margin connecting the lorica in pairs, when young

H. *Metii.*—Testules with six rays and septa, with three radiating, loosely cellular, elevated areæ, alternating with a like number of depressions, ornamented by decussating fine lines; margin (rim) wide, radiate; one or three marginal spines to each cellular space, and two to four to the other areæ; umbilicus stellate, smooth; angles not prominent. Diameter 1-372nd. Bermuda. Fossil. Has the habit of *Actinoptychus velatus.*

H. *Leeuwenhoekii.*—Eight septa and rays; cellular areæ four, and as many alternating lined spaces; rim wide, radiate; marginal spines four to the areæ of each kind; umbilical star smooth, tetragonal (P. 14, f. 35.) Diameter 1-204th. Bermuda; discovered by Dr. Bailey.

H. *Euleri.*—Ten rays and septa, with five radiating areæ of each sort; margin with spines alike in the two; umbilical star pentagonal. smooth. Diameter 1-156th. Bermuda.

H. *Selliguecii.*—Twelve radiant septa, and six radiating and alternating spaces of the two kinds, spines equal and alike in the two; umbilical star smooth, hexagonal. Diameter 1-156th. Bermuda.

Genus HEMIAULUS.—Lorica bivalve, compressed, subquadrate, fission perfect, hence not concatenate. Two tubular processes situated on each side; those of one side closed, of the other open; no constrictions on the sides.

This genus has the habit of *Biddulphia*, but is devoid of the lateral constrictions. It has the form of a Pan's pipe, with two orifices on one side.

Hemiaulus *antarcticus*.—Subquadrate, strongly granular, tridendate on each side; the central dentation shallow and obtuse—the lateral ones longer; two truncate and two opposite ones acuminate. Diameter 1-314th. (P. 14, f. 54.)

H. (?) *australis*.—Strongly granular, tridentate on each side; the central dentations very small (obsolete); the lateral rounded. Diameter 1-1152nd.

Genus Hemiptychus, (Ehr.)—Lorica composed of two equal valves, orbicular, not in chains (?). Its interior divided by imperfect septa, extending about half way towards the centre, and having no depressions on the surface, alternating with them; disc without markings, but crowned by a zone of teeth (denticuli;) apertures on the margin not evident.

This genus differs from *Actinoptychus* by its imperfect septa, by the absence of alternating depressions, by the circlet about the centre, and by the marginal apertures being obsolete. It seems, by its description, to be almost identical with *Arachnoidiscus* of English naturalists.

H. *ornatus*.—Disc minutely granular; twenty-nine equal rays, and an intervening concentric apparatus of cells. Diameter 1-120th. Found in Patagonian guano.

The individuals of this species occur as comparatively very large, thin, discoid plates, which exhibit radii upon their surface, connected by a very delicate net work, after the manner of the genus *Actinoptychus*. The radii are likewise raised bands, and extend from the margin towards the centre, but do not reach it, leaving a broad central disc, traversed by finely-dotted radiating lines, terminating at the circlet of teeth at the centre.

Genus Hemizoster, (Ehr.)—Round siliceous tubules, occurring as so many half circles, contiguous and striated.

"I (says Ehrenberg) have contrived this name, to keep in mind certain singular but not uncommon corpuscles. Are some associated corpuscles, like Pyxidicula, the lateral discs of these forms?"

H. *tubulosus*.—Testule cylindrical, two to three times longer than broad, turgid, transversely annular, resembling a portion of a trachea

(wind pipe); the rings semicircular; the extremities alternately conjoined along the centre; striæ slight, running the length of the tubule. The ends of the tubules have not been seen closed by an operculum. Length 1-386th.

Genus HERCOTHECA, (Ehr.) — Lorica composed of two unequal valves, turgid; membrane of valves continuous, not cellular, generally veined beneath an integument, or divided beneath the free setæ, which are permanent, and assume the place of an integument. Hence the corpuscles on the upper and contiguous margin of each valve appear as if crowned and enveloped, as it were, shielded, by the opposed setæ or membranes.

The forms of this genus generally resemble those of *Gallionella*, but are uot spontaneously divisible under a deciduous integument.

H, *mammillaris.* — Valves smooth, with the centre of the base fringed round (fortified), with twenty simple, opposite setæ, extending beyond a series of *mammillæ*, inserted on the margin itself. Diameter 1-816th. Fossil, Bermuda.

Genus HIMANTIDIUM, (Ehr.)—It includes several species formerly enumerated with *Eunotia.* Ehrenberg's characters unknown; those of Kützing are, "Lorica, on transverse section, rectangular; transverse striæ very fine, and very closely set; individuals conjoined transversely and closely, in the form of bands." All the forms are motionless, and unattached, neither forming fringes nor films on Conferva. They closely resemble *Fragilaria*, both in form and in their mode of concatenation, and single frustules can be distinguished from the latter only when seen on their ventral surface, and the absence of the central umbilicus thus exhibited. They are of fresh water habit, and pretty generally, though not abundantly distributed. They also occur in the fossil state.

H. *bidens* resembles *Eunotia bidens,* but developed in chains.

H. *gracile.*—Bacilli in chains, with the habit of H. *Arcus;* but only half the thickness laterally. Central and North America.

H. *guianense.*—Striated laterally; dilated in the middle; slightly furrowed, and bidendate on the dorsum: extremities attenuate, slightly reflex. (P. 15, f. 54.) Cayenne.

H. *Monodon* resembles *Eunotia Monodon,* except in being concate-

nated. It is large, striated, rather curved; ends widely rounded. (P. 24, f. 16 and 17.) North America.

HIMANTIDIUM *Papilio*.—Striated laterally, much expanded at the centre; subquadrate, furrowed dorsally, and bidendate; constricted near the obtuse apices. (P. 15, f. 45, 49, 50, 51, and 52.)

H. *parallelum*.—Linear, finely striated, curved; dorsal convexity and ventral concavity uniform, lines parellel; apices simply rounded. Ehrenberg has seen six wands united. Small specimens resemble *Eunotia Faba*. Length 1-240th. British guano.

H. *Arcus* = *Eunotia Arcus*.—Striated, convex on the dorsum; plane on the venter, constricted; ends rounded, rather recurved; striæ eleven in 1-1200th. Length 1-480th to 1-280th. By its imperfect fission it forms chains, as in *Fragilaria*. Fossil in Sweden, and living at New York, Berlin.

H. *pectinale*, (Kütz) = *Fragilaria pectinalis* (Ralfs.)—Large, very finely striated; apices on secondary side, rather incurved and rounded; the dorsum slightly expanded, plane; venter somewhat hollow. Length of frustule 1-300th.

H. *minus*. — Small, quite smooth; conjoined frustules forming elongated filaments, the dorsum and venter constituting the free or exposed surfaces. On fresh-water Algæ. Length 1-900th.

H. *Soleirolii*.—Of moderate size, very smooth; on primary side oblong-elliptic, or semi-elliptic; on secondary side, linear, lunate, with rounded apices. Length 1-384th. (P. 17, f. 13.)

H. *Veneris*.—Of middling size, quite smooth, plane on one side, convex on the other, with acute extremities. Trinidad.

Genus HYALODISCUS.—Lorica composed of two equal orbicular valves, not in chains; discs not perforated; destitute of septa; the centre of the disc separable (solubilis), valves equal, disciform, with a smooth surface. In form, it resembles *Craspedodiscus*.

H. *lævis*.—Smooth, both at the centre and margin, large, discoid· Allied to *Discoplea physoplea*. Diameter 1-456th. Virginia.

H. (?) *Patagonicus*.—Large, very smooth, flattened; suture of the valves remarkably tumid; margin of disc separable; its suture slightly sulcate, not denticulate. Diameter 1-432nd. In pumice, from Patagonia.

In Hyalodiscus *lævis*, the suture of the valves is not tumid; and not the margin only, but the central part also, of the discs, separable (solubilis). Do these two species, therefore, rightly fall together in the same genus?

Genus Liparogyra, (Ehr.)—Cylindrical, utricular, truncate. Each utricle spontaneously divisible transversely through its middle; closed at the extremities, with an internal wall, and a spiral filiform crest. No aperture evident, but minute ones may probably be present on the denticulated margin; no internal septa. If occurring in chains?

This genus, if the individuals be isolated, approaches *Pyxidicula;* but if they are concatenated, which is doubtful, it becomes allied to *Gallionella.* In habit, it approaches very closely to the non-siliceous genus of plants, *Spirogyra.*

L. *dendrochæra.*—Smooth, crystalline, margin of discs denticulated, with an internal spiral band; thirteen turns in 1-360th. Figure utricular, the length exceeding the breadth three to four times. Length 1-360th. Breadth 1-1728th. Found on the roots of water plants. Its internal contents are green when dried.

L. *circularis.*—Smooth, crystalline, margins denticulated, with internal annular filaments; thirteen turns in 1-360th. Length 1-360th.

Ehrenherg says, he has not yet determined, satisfactorily, whether the preceding are distinct species, or merely varieties of one species. Each has a smooth disc, with three central apiculi.

Genus Mastogonia, (Ehr.)—Lorica (unequally) bivalve, not in chains; valves with protuberant angles, orbicular at the base; umbilicus unarmed.

Some forms of this genus were originally placed among the *Pyxidicula,* but clearly differ by their unequal and angular valves, with radiating veins, and non-cellular surface. They differ, to a like extent, also from *Actinocyclus.*

M. *crux.*—Large, one valve with four crucial angles and rays, the other with seven, apices not truncate. Diameter 1-396th. Bermuda.

M. *quinaria.*—One valve with five angles and rays; apex not truncate. Diameter 1-480th. Bermuda.

Mastogonia *Rota.*—One valve with six angles and rays; the other with seven, apices entire. Diameter 1-360th. Bermuda.

M. *sexangula.*—One of the thin valves with six angles and rays, the other not known; apex broadly truncate, presenting an hexagonal area. Diameter 1-1632nd Bermuda.

All the above species are very smooth and crystalline.

M. *heptagona.*—One valve with seven, the other with nine rays and angles, and a truncate apex. Diameter 1-840th. Bermuda.

M. *Actinoptychus* = *Pyxidicula Actinoptychus.*—One valve with nine angles and rays, the other with thirteen. Apex broadly truncate, smooth. Rays loose and flexuose. Virginia.

M. *Oculus Chameleontis* = *Pyxidicula* O. C.—One valve with eight angles and rays, the other unknown. Apices truncate. Diameter 1-1152nd. Maryland.

Besides the above forms, single valves are met with in earth from Bermuda, having fifteen to seventeen and nineteen rays; and, in earth from Virginia, with thirteen, fifteen, nineteen, and twenty rays; and such may constitute other species.

M. *Discoplea.*—Small, valves conical, truncate; margin and area truncate, with smooth apices; eighteen to twenty rays and angles. Diameter 1-1152nd. The variety *(a)* with eighteen rays. More common, in the pumice of Patagonia; var. *(b)* with twenty, more rare, in the same substance.

Genus Meridon.—The characters of this genus agree, generally, with those of *Fragilaria*, but the frustules being cuneate (wedge shaped) form, when concatenated by imperfect self-division, circular or spiral bands. It is closely allied to *Navicula*, but differs by its incomplete self-fission, and its frustules have no central aperture, but two placed at their wider extremity; single wands (frustules) are difficult to distinguish from *Gomphonema*, but the latter possesses, besides two terminal pores, a central one also.

Kützing defines this genus, the type of his family *Meridieæ*, thus:—

"Individuals cuneiform, rectangular, prismatic; closely conjoined in flabelliform masses or in spiral bands. Transverse striæ strong, uninterrupted."

The following remarks are from Mr. Ralfs valuable papers (Ann. Nat. Hist., 1845): "This genus, together with *Styllaria*, *Gompho-*

nema, and *Licmophora*, form a group (the *Styllaria* of Agardh) distinguished by the triangular form of the frustules, which have their smaller ends directed towards a common centre. The frustules in this group have a central and two lateral portions, as in *Diatoma* and *Fragilaria;* in which genera cuneate frustules are also occasionally met with. But in *Fragilaria* or *Diatoma*, when two or more cuneate frustules are united, the alternate frustules have their ends in opposite direction, and hence their filaments are linear; whilst they are attached, if at all, only by their basal frustule. In this group, on the contrary, as the smaller ends are in the same direction, they point to a common centre, and, when stipitate, each frustule is attached to the stipes.

"Besides the two puncta at the broader end, two others, at the smaller end, more obscure, are generally present. The lateral surfaces are attenuated at the base, which usually differs somewhat from the upper end; but in the group to which *Fragilaria* belongs, they are similar at both ends, even when the frustules are cuneate."

Meridon *circulare* (Agardh.)—Frustules very minute, plane; on primary side (dorsum or face) without vittæ; on secondary side (laterally) obovate-lanceolate, with distant, strongly-marked striæ. They are partly hyaline, partly of a yellowish-green colour. The nearly circular bands occur in a mucous green stratum on mud, stones, dead leaves, &c.; in the spring, in marshes, stagnant waters, and rivulets.

This nearly = M. *vernale* (Ehr.)—It has two conspicuous puncta at the upper end, and from five to twelve along each lateral margin.

M. *vernale.*—Striated, wedge-shaped, truncate and dentate at the interior (wider) extremity, with two conspicuous puncta. Along each lateral margin are from five to twelve vittæ (Kütz), producing a beaded appearance. Fig. 177, is a spiral or nearly circular band; fig. 178, a band, with some segments separating, seen on their sides. Length of segment or frustule 1-1150th to 1-240th.

M. (?) *panduriforme.* — Sinuous, wedge-shaped, of the form of a violin. Length 1-430th. Kützing says its form is that of *Gomphonema acuminatum.*

Meridon *Zinckeni.* — Primary side with vittæ; secondary side,

obovate-lanceolate; the filament formed is curved, or nearly straight. Length 1-420th (P. 16, f. 21.)

MERIDON (?) *Ovatum* (Agardh.)—"Frustules ovate, combining to form a cellular band." Kützing mentions this as a doubtful species, described by Agardh.

M. *constrictum* (Ralfs, Ann. Nat. Hist., 1843, p. 458.)—Lateral surface constricted below the apex, transversely striated, the ends of the striæ forming puncta along the margins of the front view. Frustules united together in a chain so as nearly to form a circle, but are not arranged on a level plane, as M. *vernale*, standing nearly erect, after the manner of the staves of a tube. They agree in size and form, and in the puncta with M. *vernale*, but differ most remarkably in the constriction below the apex. Found by Mr. Jenner at Tunbridge Wells.

Genus MONOGRAMMA (Ehr.) — Lorica with transverse pinnules (striæ), and a central transverse linear space, but only traversing one half the width (a semi-crucial umbilicus); with three ventral and two dorsal apertures.

Monogramma, therefore, equals *Stauroptera*, but with a semi-crucial umbilicus; it has also a resemblance to solitary *Achnanthes*, with terminal apertures.

Species unknown.

Genus NAVICULA (Bory St. Vincent.)—*The little ship Animalcules* derived their generic name from the resemblance in form of the many species to a weaver's shuttle. According to Ehrenberg, it comprehends those members of the family *Bacillaria* which are unattached, and have a simple bivalved, or multivalved lorica. They occur single, or in pairs, but are never united in the form of a chain. The lorica of *Navicula* is a closed, mostly-four-sided, hard, and glass-like little bivalve case (*testula bivalvis*), which, in drying, often separates; when lightly pressed, it breaks or divides either into two or four longitudinal parts; sometimes the angles are provided with a short rib, distinctly furrowed, the lorica then separates into four equal parts; but in some cases the two rows of ribs are not visible, the two halves of the lorica being obliquely furrowed; it then separates into two parts. By heating the body upon platina-

leaf, the organic matter is consumed, and the siliceous lorica left clear and free. The gelatinous and diaphanous body of these animalcules occupies the whole of the interior of the lorica, and has, near the centre, a sharply circumscribed colourless bright spot. In N. *fulva*, an organ of locomotion has been seen by Ehrenberg, which he describes as a fleshy, undivided sole-like foot, proceeding from the central opening, and similar in appearance to the locomotive organ of snails. The side of the body where this foot-like process emanates, is called the ventral surface of the animalcule. This foot not only answers the purpose of allowing it to creep, but the animalcule, when at rest, can draw objects to it, and push things away by it.

Whether the two openings on the ventral surface are mouths, and the two on the back apertures for respiration, is undecided; but the opening on the back, opposite the central ventral opening, is supposed by Ehrenberg a sexual one. No direct demonstration of the nutritive apparatus has yet been effected by using coloured food, though numerous scattered and colourless vesicles are to be seen within the bodies of several species, which indicate polygastric structure; but what Corda took for an alimentary canal (in *Pharyngo glossa*) was merely the dark central longitudinal furrow of the lorica. This genus is more complex in its structure than the two preceding; and many consider these beings as animals. The green, yellow, and brown colouring matter in their interior, supposed to be ova, occurs in the form of broad plates or fillets, from two to four (8 ?) jointed together in the middle. These plates take the exact form of the interior of the shell, filling the cavities of the flutings, furrows, or striæ. In many species, two or four round vesicles are seen, which, although they are not changeable in form, or contractile, yet are sometimes present and sometimes absent, ana are probably analogous to small seminal glands. Many *Navicula* multiply by spontaneous self-division, in which case it is invariably longitudinal, and dorsal, or lateral; the division taking place beneath the hard epidermis, as in *Gallionella* and *Achnanthes*, and the lorica separating afterwards. It is seldom in this genus that a second self-division commences before the first is complete and separation takes place; indeed, species whose individuals separate into four, should be placed in *Fragilaria*.

The following observations are from more recent investigations of Ehrenberg :—

In the small pools left by the ebb of the tide near Cuxhaven, he remarked numerous little bodies, apparently similar to *Navicula, Surirella elegans,* and S. *striatula,* but which, from their comparatively very great size and structure of lorica, were easily distinguishable from them upon closer examination. One of these ribbed oval glass-like creatures, which belonged to the genus *Navicula,* was, besides its size, remarkable for its great mobility, and Dr. E. was enabled to investigate its system of locomotion much more satisfactorily than he had hitherto done in any member of the genus. This organ he states was very different, both in form and size, to what he had before noticed. Instead of a snail-like expanding foot, long delicate threads projected where the ribs or transverse markings of the shell joined the ribless lateral portion of the lorica, and which the creature voluntarily drew in or extended. An animalcule 1-18th of a line long had twenty-four for every two plates, or ninety-six in the total; and anteriorly, at its bread frontal portion, four were visible. The openings for the purposes of nutrition appeared to be at the extremity. Whether these organs were supernumerary, and existed along with cirrhi, &c., and the flat snail-like foot, which the rest of the *Naviculæ* possess, could not be determined. Longitudinal clefts at the broad side of the shell were not present, but as many as ninety-six lateral openings for the exit of the cirrhi were perfectly distinct. It is probable this creature may form the type of a special group of the *Bacillaria.* Of one thing Dr. E. is convinced, that the *Naviculæ* in general are very differently constituted individually; thus, in some cases, the six round openings in the little shell are distinctly visible, whilst in others, clefts, which in some cases gape, and are unprovided with circular openings, are all that can be made out.

The fleshy, undivided, sole-like foot, lying close upon the lorica, described by Ehrenberg in some of the large forms of *Naviculæ,* has not been observed by any other microscopist. Kützing says he has failed to discover this locomotive process, though he has searched most narrowly after it. Neither, again, have Ehrenberg's views, respecting the presence of locomotive cilia, capable of being protruded

and retracted through openings in the lorica, met with any support from other naturalists. Some few, indeed, have seen hair-like appendages to the lorica of *Surirella Gemma,* and also to that of some other *Diatomeæ,* but none have witnessed any power of motion in them, and their presence would seem almost accidental. (See note on *Surirella Gemma,* by the Rev. W. Smith, p. 404.) Dujardin affirms, as the result of most minute and painstaking investigations, that foot-like processes, and moving cilia, have no existence in any *Navicula.*

Ehrenberg's assumption, that the clear vesicles, often seen in the interior of *Navicula,* are seminal vesicles, is recognized by no other naturalist. Kützing says they are oil-vesicles, without any true enclosing wall, occurring at hazard, capable at any time of coalescing on approximation, and distributed irregularly, and in varying abundance, amid the contained amylaceous chlorophyl of the lorica.

In seven species of *Navicula,* Ehrenberg proved, to his mind, the stomach-like nature of the globules seen in their interior, by the supposed visible imbibition of an artificially coloured solution in which the *Naviculæ* were placed. These so-called stomach vesicles vary in number and position in the same species; their distribution is, for the most part, quite irregular, and sometimes they are entirely wanting. This last circumstance, Kützing remarks, is opposed to the belief in their digestive functions, for surely such important organs as stomach should never be absent. Moreover, other experimenters have failed to get any colouring matter introduced within the lorica of *Naviculæ.*

Both Kützing and Ehrenberg coincide in the opinion of the circular spots of the lorica being actually pores; and the former describes them as furnishing an exit for the gelatinous substance which is found to invest some *Naviculæ,* and is especially remarkable in the case of those genera having, as Ehrenberg terms it, a double lorica, such as *Schizonema.* In opposition to this notion of the lorica being porous, Schleiden gives engravings to prove that the apparent openings are but depressions of the surface, and have no communication with the interior. Dujardin affirms, on the contrary, that they are elevations (see p. 399, and Plates 19 and 20.)

The lorica of *Naviculæ,* as of other Bacillaria, is generally con-

cluded to be composed of two lamina, or an outer and inner membrane, the distance between the two being its thickness. Ehrenberg inclines to the belief that the striæ and pinnules are but furrows upon or within the lorica; but Schleiden represents them as clefts, penetrating between the outer and inner lamina, or lamella (P. 18, f. 1 to 6.) In this matter, too, Schleiden is supported by the independent testimony of the Rev. W. Smith (Ann. Nat. Hist., vol. 7, 1851, p. 8) who describes the costæ of *Surirella*, &c., as tubes passing between the siliceous valves and the inner membrane; but to this, he adds, "that those canals communicate with the exterior by a series of perforations," (p. 401.)

The clear longitudinal bands or fillets, seen in many *Navicula*, are also held by Schleiden to be clefts like the pinnules (P. 18, f. 2, 3, 5) but, by Dujardin, they are considered to be elevations or thickenings.

The prevailing opinion is, that the frustule or lorica of *Naviculæ*, is inherently one-celled, without any internal subdivisions. The double contour, which denotes the thickness of the wall of the shield (lorica) may be seen to terminate suddenly both above and below." "This," says Schleiden (Principles of Botany, translated by Dr. Lankester, 1849, p. 594), "clearly shows that a passage exists from the top to the bottom of the shield." This structure is still better shown by an oblique section, which may be obtained by taking some of the siliceous earth of Erbsdorff, and mixing it with mucilage, and, before it is perfectly hardened, cutting off delicate plates with a razor (P. 18, f. 4.)

Now it has been proved, that cells, whether animal or vegetable, have, at some period of their existence, within them, mostly seated on one part of their wall, a small circular body, called the *nucleus* or cytoblast, and which Schleiden conceives to precede the cell itself, and give origin to it. Among the Algæ, till of late, this organ was known only in *Spirogyra*, but Nägeli (Ray Society, 1845, p. 221) affirms that, "in a species of *Navicula*, in the centre (whether lying on the membrane or free, I know not), is a nucleus with a nucleolus." (See genera Gallionella, and p. 377.)

This genus *Navicula*, from recent researches, now numbers so many species, that, for convenience of description and reference, it has become necessary to break it up into several sub-genera. Ehren-

berg in his great work, (the number of species being then comparatively few,) contented himself by making two sub-genera, *Navicula* and *Surirella*, the former without, the latter with, transverse striæ. To these two he has subsequently added *Pinnularia*, *Stauroneis*, and *Stauroptera*, making in all five sub-genera of what is called the genus *Navicula*, but which might, indeed, be called rather the family *Naviculeæ*.

Moreover, not a few species, enumerated in 1838 with *Navicula*, have been since transferred to other genera—themselves mostly new.

In framing the characters of his sub-genera of *Navicula*, Ehrenberg has had recourse to the circumstance of the presence or absence of a median aperture or umbilicus, and its form, in conjunction with that of the presence or absence of transverse striæ. Where, on the other hand, that author has entirely transposed species from *Navicula* of 1838, to other genera, he has been especially guided by the number and disposition of the apertures, coupled with the form of the lorica, and its occurrence or non-occurrence in a concatenated manner

The following plan represents the sub-genera of *Navicula*, with their mutual relations and distinctions (exclusive of the sub-genus *Pleurosigma* of the Rev. W. Smith,—appended.)

Navicula.	Without a central aperture			Surirella.
	With a central aperture or umbilicus.	Umbilicus rounded	Smooth, or longitudinally striped	Navicula.
			Transversely striated	Pinnularia.
		Umbilicus crucial	Smooth or longitudinally striped	Stauroneis.
			Transversely striated	Stauroptera.

This sub-division of *Navicula* is not approved of by Kützing, so far as it rests on the circumstance of the presence or absence of transverse striæ, since, as he affirms, these striæ are variable, and cannot be used as generic characteristics.

But this writer employs, unhesitatingly, in defining genera, the characters to be drawn from the presence or absence of a median aperture, from its form, and from the position and number of other apertures, as also from the figure of the lorica on a transverse section, or viewed end-ways.

Kützing would appear, indeed, to assign a higher importance to the presence or absence of an umbilicus than even Ehrenberg, for he has constituted *Surirella*, with some other genera, into a family *Surirelleæ*, totally distinct from the family *Naviculeæ ;* in fact, *Surirella* and *Navicula* belong to two different *orders ;* the former, devoid of an umbilicus, to the *Astomaticeæ ;* the latter, possessing an umbilicus, to the *Stomaticæ.*

According, therefore, to the foregoing opinions, Kützing retains the transversely striated and umbilicated *Pinnularia* with the smooth, umbilicated *Navicula;* as likewise the smooth *Stauroneis* with the striated *Stauroptera.*

A still more remarkable plan, pursued by the author just named, is, the including in his family *Naviculeæ* those peculiar organisms, having the outward general figure of minute, branched, or tufted Algæ, but intimately composed of innumerable, mostly minute, navicula-like bodies, enveloped in a gelatinous investment or thallus and which Ehrenberg described as *Bacillaria* with a double lorica. With these compound organisms, indeed, a relation is sometimes displayed by species of free *Navicula*, which are surrounded by more or less mucus; but the first-named beings seem to form a more natural group by themselves. To trace an analogy, they bear the same relation to the free, isolated *Navicula*, as do the polyparies of coral, or other aggregated polypes, to the simple polypes having an individual or isolated existence.

This point is partly conceded by Kützing, who divides his family *Navicula* into two sections:—viz. *(a.)* True *Naviculeæ*, and *(b.) Schizonemeæ*. In the first section he locates the following genera:—viz., *Navicula*, *Amphipleura*, *Ceratoneis*, *Stauroneis*, *Amphiprora*, *Amphora*, and *Diadesmis ;* in the second, *Frustulia*, *Berkeleya*, *Rhaphidogloea*, *Homococladia*, *Schizonema*, *Micromega*, and *Dickieia.*

Surirella, as before remarked, gives name to a distinct family in the system of Kützing—*Surirelleæ* ; which, in addition to that genus, comprehends *Campylodiscus*, *Bacillaria*, and *Synedra.*

On the sub-division and structural peculiarities of this great genus *Navicula*, the Rev. W. Smith, in a recent paper (Ann. Nat. Hist Jan. 1852), has the ensuing remarks:—

"I shall restore the genus *Pinnularia* of Ehrenberg, rejected by

Kützing, and adopt the term *Pleurosigma*, as descriptive of another group. The genus *Navicula* of Kütz., and other writers, will then be resolved into three, whose characters may be given as follows :— 1. *Pleurosigma*. Valves convex, sigmoid striated; striæ resolvable into dots. (P. 20, f. 17, 18, 19.) 2. *Navicula*. Valves convex, lanceolate or elliptical, smooth or striated; striæ resolvable into dots. 3. *Pinnularia*. Valves convex, oblong or elliptical, ribbed or pinnated with distinct costæ, not resolvable into dots. . . . "In *Pleurosigma*, the resolution of the striæ into their constituent beads becomes a task of extreme difficulty, and has, from this circumstance, been very generally adopted by microscopists as a means of testing the object-glass of a microscope. The presence of striæ, on the valves of *Pleurosigma* and *Navicula*, may be known, even when the power employed is insufficient to detect lines, by the colour of the dessicated frustules viewed by transmitted light. This colour differs in each species; it arises from the refraction of the rays passing through the siliceous plate, and its shades depend on the direction of the striæ, and their distance from each other; its aid may therefore be evoked in the discrimination of species, and will sometimes be found the most facile and certain means of identification.

"In the *Naviculeæ* generally, each valve is traversed by a median line, across which the striæ do not pass. The centre and extremities of the line are somewhat enlarged, and these enlargements have been regarded by many writers as openings in the siliceous plates. I have never been able to satisfy myself that such openings exist, and am disposed to regard the line itself, and its enlargements, as peculiarities little connected with the essential structure or functions of the cell. More important, in a structural point of view, is the form of the connecting membrane, which, in *Pleurosigma*, consists of a narrow ring of silex, and which in no period of its growth appears to have any very considerable development. The consequence is, that the frontal (lateral, Ehr.) view of the frustules is uniformly of a linear, or, when the convexity of the valves is considerable, of a linear lanceolate form, while in *Navicula* and *Pinnularia* (P. 18, f. 2, 20, 22, 23), as the connecting membrane is often more fully developed, the front view of their frustules is frequently oblong or quadrilateral. Two much importance must not, however, be attri-

buted to this aspect of the Diatomaceous frustules, as its form greatly depends upon the stage to which self-division has arrived, and may vary from linear to oblong, or from very narrow to very broadly lanceolate, in the same individuals. In p. 20, f. 13, is an illustration of multiplication by self-division in *Pleurosigma.* That by this mode *Naviculeæ* multiply to a surprising extent, is evident, from the circumstance of so great numbers being found together nearly all of exactly the same size; but it is also certain that they, like some other *Diatomeæ,* have a specific mode of reproduction, since we often find frustules in various stages of growth, as is evident from the diversities of their size, (P. 19, f. 7 and 9; p. 20, f. 1 to 3, 9 to 12), and from the greater delicacy of the striæ in individuals of the same species; circumstances which are incompatible with the process of self-division, where the half new frustules must of necessity be precisely counterparts of the old. The mode in which the germinative power is renewed, when exhausted by self-division, will probably be found to be a process analogous to that of conjugation in the *Desmidieæ,* and in some of the *Diatomeæ.* . . . . The figures of *Pleurosigma,* in p. 19 and 20, are drawn by the camera lucida to a scale of 400 diameters."

In Ehrenberg's arrangements, *Navicula* gives name, and is the type of the section *Naviculacea,* of the great family *Bacillaria,* although the characters of many of the forms introduced are far removed from those of the genus *Navicula,* and any affinity with them scarcely traceable.

The only connecting link between the genus *Navicula* and many of the so-called *Naviculacea,* is the siliceous nature of the lorica; however, *Navicula* has close affinities with a large number of other genera; and each of its sub-divisions has also its own special relations: what these severally are is pointed out under the head of each genus. Still it is very difficult, oftentimes, to assign to its proper genus each navicula-shaped lorica which may be met with, especially when but one or two at a time occur, and then only probably one surface presented to view; or when the right portion is to be determined by the fact of its attachment or non-attachment, and only detached frustules are to be had, either from accident or from their occurrence, in a fossil state.

The difficulty is illustrated by the fact, that of the forty-five species of *Navicula,* described after Ehrenberg, in the former edition of this work, ten have been since transferred, by that most accurate observer of species, to other distinct genera, apart from the many re-distributions he has made among the several sub-genera.

Kützing separates several species from *Navicula,* by reason of their being symmetrical; that genus being peculiar in always having a symmetrical lorica,—*i. e.,* one equally developed on each side the central umbilicus. Those species so removed, are included in the genus *Cymbella.*

Sub-genus Surirella.—Striated; no umbilicus; in both these circumstances differing from *Navicula;* and, in the latter of the two, from *Pinnularia.* The following additional characters and remarks are from the recent valuable contribution in the *Annals of Natural History,* by the Rev. W. Smith. (1851, p. 7.) "Valves concave, with a longitudinal central line, and margins produced beyond the suture (winged.) Frustules free, solitary, or, when undergoing self-division, in pairs. The concavity of the valve, their winged margins, and the longitudinal central line, which wants the central depression (umbilicus), so conspicuous in the *Naviculeæ,* are characters which sufficiently distinguish *Surirella* from all other genera."

Mr. Smith has detected alæ in six species (S. *biseriata, splendida, gemma, fastuosa, craticula*), and he believes them present in all. It is only on an end view of the valves, but rarely to be obtained, that the alæ can be clearly seen.

"The costæ, so conspicuous in several species, as well as in *Campylodiscus costatus* and *spiralis,* appear to be caused by canals or tubes passing between the siliceous valves and the inner membrane of the cell; these canals communicate with the exterior by a series of perforations, along the suture or line where the connecting membrane unites with the valves. Accepting the Diatom as a vegetable organism, these tubes will be regarded as analogous to the intercellular passages, and the exterior perforations will perform the office of the stomates of the leaf. (At most, these perforations can have but a remote analogy with stomates, for these organs are peculiar

to air breathing plants, and absent in submerged ones. In S. *biseriata,* and S. *splendida,* the costæ or undulations caused by these tubes are continued to the margins of the alæ, and gives a singularly beautiful appearance to the front view of the frustule."

The so-called costæ are otherwise called, by Ehrenberg, transverse striæ or pinnules; but in the species named, as well as in others, the striæ are not mere single lines, but have a double contour, and an apparent prominence or depression.

Surirella *Librile.*—Elongate, oblong, slightly constricted at the middle; ends sub-acute, rounded or apiculate; the last condition is, however, more common with young or smaller specimens. Transverse striæ eight in 1-1200th. Lateral aspect linear, oblong, with rounded truncate ends, divided by a central clear line, on each side of which is a wavy band having about six undulations. Group 155, represents both aspects. Alive at Gravesend and elsewhere; fossil at San Fiore, Mexico, &c.

S. *striatula.*—Ovate dorsally, with small alæ; striæ strong, curved; ends rounded (fig. 137); laterally (on front view, Smith) cuneate and elliptical; ends rounded, very broad, (fig. 138); alæ small; striæ eight to thirteen in 1-1200th. This form was discovered by Dr. Surirey in 1826, and preserved alive for eighteen months. It is very transparent and colourless; its motion, when observable, is slow. Alive on the English and French coasts; fossil in Bohemia. Length 1-3450th. to 1-60th.

S. *undulata*=*Denticula constricta* (Kütz.)—Striated, large, elliptical, ends rounded; laterally, linear and truncate; margin prominently dentate, with a flexuose band running longitudinally on each side. Striæ four in 1-1200th. (fig. 149 represents an oblique view.) Found amongst *Oscillatoria.* Length 1-210th.

S. *constricta* = *Denticula undulata* (Kütz.)—Striated, large, oblong, slightly constricted at the middle on the ventral surface; ends obtuse, truncate; striæ three to four in 1-1200th. Laterally oblong, extremities dilated, rounded; the margin dentate. Alive at Berlin. Length 1-210th.

S. *constricta* (Smith)—Frustules on front view oblong, with rounded ends; outline on side view elliptic-lanceolate, each margin having a central sinus; alæ distinct; costæ numerous, delicate;

medial lines inflated in the centre. Average length of valve 1-300th.; breadth at constriction 1-850th. In brackish water near Lewes.

The front view of this species bears a close resemblance to the same aspect in S. *biseriata*, (Smith) differing only in the appearance of the costæ, which, in the present, assume the character of striæ rather than ribs. On the side view the constriction of the margins, the inflation of the central furrow, and line-like appearance of the costæ, afford sufficiently distinctive characters. The superficial observer, regarding the side view only, might indeed confound this species with immature specimens of *Cymatopleura solea*, but a slight examination shows that the resemblance is one of outline merely.

This seems an independent species, but it is unfortunate that its discoverer has applied to it a name already in use to designate another.

Surirella *splendida*.—Striated, on front view, ovate-oblong; ends rounded (fig. 150, 151, and 152). Transverse striæ strong, rib-like; alæ large; striæ, two in 1-1200th. "In June, 1837," observes Ehrenberg, "was the last time I saw this species. The specimens resembled Turpin's *Surirella striatella*, found in the sea at Havre, but were, nevertheless, distinguishable by their form and stripes. I saw them move very often. The plates of the ova clusters are toothed, and of a golden yellow colour." Length 1-210th. to 1-100th. Found both living and fossil.

S. (?) *bifrons*.—Striated; resembles the preceding, but both ends of the lateral surface are acute, and those of the ventral, truncate. Three-and-half striæ in 1-1200th. Common; living amongst *Oscillatoria*, and fossil in the Isle of France. Length 1-210th. to 1-100th.

This species = S. *biseriata* (De Brébisson), the name adopted also by the Rev. W. Smith, who observes, in his note on this form, "In living specimens I have noticed a circulation of the granular contents, analogous to that which is seen in many of the *Desmidieæ*, and in the cells of the higher order of water-plants; a further proof that it is a single cell, and a presumptive evidence of its vegetable nature."

S. *folium*.—Ovate, turgid and obtuse, slightly compressed, central

aperture not present; striæ narrow, twenty-four in 1-1150th. Length 1-540th.

SURIRELLA *Gemma.*—Ovato-oblong, large, turgid, central aperture not present; striæ slender, sixteen in 1-1150th. Alive at the mouth of the Elbe, and in various tidal harbours of England. Length 1-290th. to 1-220th.

S. *Gemma.*—Mr. Smith says—"Frustules on front view wedge-shaped, with rounded ends; side view ovate-elliptical; alæ large; costæ small, unequally distant; surface of valve distinctly striated. The striæ are made out with difficulty on the dry valve after burning or maceration in acid. Its costæ are linear, unlike those of S. *striata, craticula, constricta,* &c. (P. 15, f. 2, 3, and 4.)

"It was in connection with this species, that Ehrenberg records the presence of cilia, extending from the aperture of the costæ, vibrating with rapidity, and being extended or retracted at intervals. (P. 15, f. 3 and 4.) The presence of delicate hairs, apparently on all parts of the frustule, may often be detected; and I have noticed them on nearly every occasion when I have gathered this species, but in no case have I been able to perceive any motion in such hairs, and concluded, before meeting with Ehrenberg's remarks, that they were merely a parasitic growth, the mycelium of some other algæ. I have noticed similar appendages to other *Diatomaceæ,* but in every case devoid of motion."

S. *Clypeus.*—Large, ovate, obtuse, with nine very broad pinnæ in 1-276th. Marine. Length 1-276th.

S. *craticula.*—Lanceolate, with large alæ; apices on the dorsal aspect acute; on the lateral, truncate; and figure oblong, with centre slightly inflated; pinnules seven in 1-1200th. Length 1-288th; smaller than S. *bifrons*; costæ fewer, and those divergent. (P. 15. f. 19 and 20.)

S. *fastuosa.* — Larger, elliptic; alæ small; pinnules dilated gradually, eighteen on each side, in 1-360th, which is its length; central portion of valves smooth; apertures of costal tubes large.

S. *lamella.* — Large, lamellar, ovate-lanceolate, slightly keeled; striated only on its extreme margin, the whole central space being granular; laterally narrowly linear, and truncate. Length 1-216th. to 1-180th.

Surirella *robusta*, (formerly associated with *Navicula bifrons.*)—Large, elliptic, elongate, with two very strong pinnules in 1-1200th. Length 1-216th to 1-120th. Fossil in the siliceous meal of Finland.

S. *Testudo.*—Large, ovate, obtuse, with twelve slender pinnules in its length, which is 1-288th.

S. *Campylodiscus.* — Small, ovate-elliptic; ends equally rounded; flexuose, like *Campylodiscus;* margin striated, with ten to twelve pinnules on 1-1200th. Mexico. (P. 15, f. 12, 13, 22, and 23.)

S. *decora.*— Large, elongate, sides straight, extremities equally acute; pinnules small, four to five in 1-1200th. North America.

S. *elegans.*—Large, broad; surface with very minute dots; ends subacute; pinnules four in 1-1200th.

S. *euglypta.*—Smaller, ovate, oblong, smooth; one extremity more tapering than the other, but both obtuse; pinnules seven in 1-1200th. Mexico.

S. *flexuosa.*—Larger, flexuose; pinnules four to five in 1-1200th (only a fragment examined); approaches *Campylodiscus.* Mexico. (P. 15, f. 11.)

S. *Microcora.*—Very small, smooth, lanceolate; ends short, acute, equal; pinnules marginal, ten in 1-1200th. Cayenne, Mexico.

S. *myodon.*—Small, narrow, elongate, rather curved; ends rounded; pinnules small, closely set, and giving the margin a toothed appearance, six to seven in 1-1200th. Mexico.

S. *oophæna.*—Larger, view on the sides ovate, plicate-undulate; one end widely rounded, the other tapering, but obtuse; there are five transverse but obscure plicæ (undulations); pinnæ small, six in 1-1200th. Falaise and Mexico.

S. *Peruviana.*—Very large, but narrow and elliptic-lanceolate; extremities equally obtuse; pinnules very small, faint, about twelve in 1-1200th. Peru.

S. *Regula.*—Small, linear, sides straight, with six bands, ends cuneate; pinnules ten in 1-1200th; almost obsolete. Mexico.

S. (?) *paradoxa.*—Small, and not pinnate on the navicular sides, linear-elongate, elliptic, and ends rounded. Length 1-576th. Caltanisetta, Sicily.

S. *rhomboidea.*—Smooth, not pinnate on the sides, which are rhomboid; ends obtuse on back, linear. Length 1-744th. Caltanisetta.

SURIRELLA *Sicula* = *Navicula Sicula.*—Smooth, and broadly navicular laterally; the margin with longitudinal lines; ends subacute. Length 1-528th.

SURIRELLA *Amphibola.*—Striated, and widely linear; on the lateral surface cuneate, subacute at the extremities; on the dorsal aspect, ends obtuse; pinnules fifteen in 1-1200th. Length 1-324th. Has the general form of S. *Regula.* Kurdistan.

Ehrenberg remarks, that he is not sure to what genus this belongs; he has sometimes thought a slender umbilicus existed, as in *Pinnularia;* but its form is singular, in presenting equal transverse striæ on each side.

S. *brevis.*—Short, striated; has the figure and size of S. *striatula,* but its striæ are larger and more slender; sixteen in 1-1200th. Length 1-912th. Kurdistan.

S. *Lepida.*—Slender, linear lanceolate, one end extremely obtuse, the other more tapering and subacute; striæ nine to ten in 1-1152nd; a distinct curved line extends along the centre on each lateral aspect. Length 1-768th. Kurdistan.

S. (?) *elliptica.*—Elliptic-oblong; a slight longitudinal line extends down its centre, and it has parallel transverse striæ. Length 1-480th. In form approaches the genus *Rhaphoneis.*

S. *crenulata.*—Ovate lanceolate, margin crenulate; ends somewhat unequal, subacute; eleven crenules in 1-1152nd, extending into pinnules. It has also a distinct median suture. Diam. 1-1080th. Fossil.

S. *lævigata.*—Lanceolate, elongate, smooth, ends obtuse, somewhat unequal; a distinct median suture exists, with two longitudinal lateral lines. Length 1-168th.

S. *leptoptera.*—Lanceolate, ends acute, rather unequal; pinnules dense, six in 1-1152nd; median suture dilated, distinct. A specimen, 1-456th long, presented twenty-one pinnules. Fossil, Oregon.

S. *Oregonica.* — Spathulate in figure, ends subacute, unequal; median suture broad and distinct; pinnules strong; about the middle, from four to five in 1-1152nd. Length 1-336th, and in this nineteen pinnules were met with. Fossil.

S. *reflexa.* — Lanceolate, extremities unequal, subacute, slightly reflexed; central suture distinct; pinnules strong, about centre three to four in 1-1152nd. Length 1-180th. Fossil in Oregon.

Surirella (?) *linea.*—Bacillar, large; one side cuneate, the other rounded, minutely and transversely striated throughout. Length 1-240th.

S. *stylus.*—Large, styliform, and narrow, quadrangular; one end more obtuse than the other, but neither acute; pinnules fifty-four in 1-144th. Length 1-144th.

S. *Caledonica.*—A species discovered by Ehrenberg, in earth sent from Ireland.

S. *plicata.*—From the same source.

S. *aspera.*—Large, with loosely disposed pinnæ, which also present rough crests, four to five in 1-1152nd. Ehrenberg says, "I have seen but a fragment, if a *Campylodiscus?*" From volcanic earth, Hochsimmer, on the Rhine.

S. *spiralis* (Kütz.)—Primary side linear, spirally twisted, with a dotted margin; dots five to six in 1-1200th. Length 1-300th. Nordhausen.

S. *didyma.*—Oblong, truncate at each end, sinuate, constricted at the middle; margin punctate. Length 1-600th.

S. *solea* = *Surirella Librile* (Ehr.)

S. *multifasciata.*—Narrowly linear laterally; dorsally cuneate, acute at each end; transverse striæ very fine, obsolete. Length 1-288th.

S. *thermalis* = *Pinnularia* (?) *thermalis* (Ehr.)

S. *ambigua* (Kütz.)—Broadly oblong, truncate at each end; transverse striæ rather wide, straight, obsolete, four in 1-1200th. Length 1-264th. Bernese, Oberland.

S. *oblonga.*— One end attenuate, broadly obtuse, and rounded, sinuoso-dentate near the margin. Marine.

S. *elliptica* (Kütz.) = S. *oophæna* (Ehr.) see *Cymatopleura elliptica.*

S. *Patella.* —Elongated, elliptic, equally rounded at each end; marginal striæ four to five in 1-1200th. Length 1-300th. Fossil.

S. *augusta.*—Minute, linear-oblong on sides, rectangular dorsally, equally rounded at both ends, with the margin finely striated; striæ eleven in 1-1200th. Length 1-600th. Alive in ponds, Nordhausen.

S. *ovalis.*—Oblong and cuneate; laterally ends truncate; dorsally ovate-elliptic, the one end more narrowly rounded than the other; marginal striæ eight in 1-1200th. Length 1-360th to 1-280th. Costæ only visible at margin of valves. Freshwater.

Surirella *ovata.*—Small, laterally widely cuneate and truncate; dorsally ovate, with delicate marginal striæ, seven to nine in 1-1200th.

Var. *(b.)* dorsally equally elliptic. Length 1-1200th to 1-560th. Common in ponds.

S. (?) *ornata.*—Elongate, truncate at each end, with obtuse angles; longitudinally cleft, and ornamented with minute puncta, disposed in decussating lines. Length 1-280th. Breadth 1-960th. Among Algæ, Genoa. Kützing has seen this form but once.

S. (?) *Adriatica* = *Podocystis Adriatica.*—Small, supported on a short stipes, cuneate laterally; dorsally obvate; striæ transverse, eleven to twelve in 1-1200th. On Callithamnion, at Trieste. Length 1-620th.

S. *minuta,* (Smith.)—Frustule on front view (laterally Ehr.) wedge-shaped; on side view (dorsally, Ehr.) elliptical or slightly ovate, with ends more or less rounded; costæ marginal. Average length 1-1200th. Greatest breadth 1-2500th. In streams.

S. *salina* (Smith.)—Frustule on front view wedge-shaped; on side view ovate; the larger end rounded, and the smaller more or less pointed; costæ marginal. Average length 1-600th; greatest breadth 1-1200th. In salt-water ditches, Poole Bay.

"This nearly resembles S. *minuta,* but is a salt-water species, usually larger and distinctly ovate, and with the smaller extremity of the valve, in most of the frustules, somewhat attenuated. On the other hand, it is much smaller than S. *ovalis* (Kütz.) less oblong and stout, and of marine habitat.

S. *circumsuta* (Bailey.)—Outline nearly elliptical, with a scarcely perceptible constriction at the middle; surface with very minute granulations, and a faint longitudinal line through the middle; edges with a continuous row of nearly obsolete pinnulæ. Hudson River, west points of Florida.

Sub-genus Navicula—*True Navicula.*—Lorica smooth, or with longitudinal lines or stripes; central aperture round. This last circumstance distinguishes it from *Stauroneis,* whilst its general symmetry separates it from the smooth forms of *Cocconeis,* which has one surface depressed or flattened.

Navicula *gracilis.* — Smooth, slender, lanceolate; ends acute laterally, linear, truncate. Common; freshwater and fossil. Length 1-1500th to 1-560th.

N. (?) *pellucida* = *Amphipleura pellucida* (Kütz.)—Slender, lanceolate, smooth (no median aperture, Kütz.), see fig. 140, which represents a group, and a transverse section, to show the position of the central furrow on each side. Found with the preceding. Length 1-300th to 1-140th. It has the general form of a *Closterium;* and the apparent absence of an umbilicus, would certainly determine its position with some other genus than *Navicula.*

N. *acus* 1838 = *Ceratoneis acus* (Ehr.) and *Synedra subtilis* (Kütz.)

N. *umbonata.* — Smooth, straight, constricted near the middle, causing the ends to appear larger, hence its name. Length 1-430th to 1-240th. Salt and fresh water, and fossil. Kützing adduces this as his *Surirella thermalis,* and the *Pinnularia* (?) *thermalis* of Ehrenberg; and, as is thus implied, furnished with transverse striæ, delicate though they are. If such striæ exist in any degree, this species should certainly be excluded from the present sub-genus.

N. *fulva.*—Smooth, broadly lanceolate; slightly produced at the ends in the form of a beak or rostrum (*i. e.* ends *rostrate*), colour yellowish-brown; umbilicus very small, round; lateral aspect narrowly linear and truncate. Length 1-1150th to 1-180th (P. 15, f. 5.) Alive and fossil.

N. *amphisbæna.*—Smooth, broadly elliptic (see group 141), apices much contracted; umbilicus circular; granular contents of golden-yellow colour. Ehrenberg remarks, that the vibratile process, seen by Bory St. Vincent, was, in fact, the locomotive organ, the action of which is readily seen, though the process protrudes but a very little beyond the lorica. Length 1-1700th to 1-240th. Fresh water.

N. *nodosa.*—Smooth, linear, with three undulations on each side, about the middle; extremities contracted, shortly rostrate and obtuse (see fig. 143.) Central opening round. Length 1-430th.

N. *Cari.*—Slender, lanceolate, smooth; ends acute; umbilicus circular. Length 1-1150th. Fossil at Cassel.

N. *Baltica.*—Large, smooth; sigmoid, by the curvature of the attenuated obtuse ends in opposite directions (fig. 144.) Central

opening small, round. Length 1-70th. Found in phosphorescent sea-water.

NAVICULA *hippocampus.*—Smooth, sigmoid, lanceolate; apices obtuse; laterally linear and truncate (group 145.) Sometimes it has delicate longitudinal striæ. Length 1-90th to 1-70th. In fresh and salt water. This shell is the well-known test for microscopes. See descriptions of Plates 19 and 20.

N. *Sigma* = N. *acuminata* (Kütz.)—Smooth, lanceolate, sigmoid, ends attenuate, obtuse; laterally straight (group 146.) It often contains motile granules, and has a golden-yellow colour. Length 1-210th to 1-140th. In fresh and salt water.

N. *scalprum.*—Smaller, slightly sigmoid; apices gradually tapering, obtuse, with longitudinal lines. Length 1-430th to 1-290th.

N. *curvula.* — Narrow, linear lanceolate, sigmoid, apices rather obtuse; no longitudinal striæ. Lateral view straight. Fresh water.

N. *Trochus.*—Short, smooth, enlarged at the centre, constricted near the ends, which are much produced and truncate. The surface is marked by several longitudinal stripes. Length 1-860th. Fossil in Sweden.

N. *Agellus.*—Large, of a sigmoid lanceolate figure on the back, with very fine longitudinal lines, and having a furrowed space; straight and nearly linear on the side, with subacute extremities. Length 1-180th It is more slender and longer than N. *Hippocampus.* In fresh water. Common.

N. *binodis.*—Probably but the young of N. *bibrile.* Fossil at San Fiore, Italy = *Fragilaria binodis* (Ehr.) 1843.

N. *carinata.*—Lanceolate, linear laterally, and with a broad longitudinal dorsal keel. Length 1-216th. Fossil on shores of the Rhine in volcanic schists.

N. *eurysoma.*—Small, ovate; ends obtuse; quite smooth; margin distinct. Found in African chalk-marl. Not improbably a *Cocconeis.*

N. *inversa.*—Short, dorsally narrow and sigmoid, with subacute ends; laterally quadrangular, very broad, constricted at the centre, with the ends widely truncate, and marginal glands (?) It moves quickly; is allied to N. *alata,* but wants the winged portions. Length 1-576th.

Navicula *rostrata.*—Large, very broadly lanceolate, almost rhomboid; extremities acute, rostrate. Central aperture large, lateral view linear, truncate, Length 1-216th. Fossil.

N. *affinis.*—Linear dorsally, constricted at each end, which is shortly rostrate and obtuse. Approaches *Pinnularia dicephala.* Length 1-570th to 1-420th (P. 15, f. 32.)

N. *ambigua.*—Linear-oblong dorsally, subventricose, contracted at each end, which is produced but obtuse. Resembles very closely the former species.

N. (?) *Americana.*—Oblong and turgid dorsally, slightly constricted in the middle; ends widely rounded.

N. (?) *amphigomphus.*—Larger, oblong; sides smooth; ends wedge-shaped, with or without faint longitudinal lines.

N. *amphioxys.*—Dorsally narrow, linear lanceolate, without longitudinal lines or striæ, attenuated at the ends, subacute. More elegant in figure than N. *gracilis.*

N. *amphirhynchus.*—Dorsally elongated, lanceolate, suddenly constricted towards the ends, which are produced and truncate (P. 15, f. 6.) Has a wider form than N. *amphisbœna.*

N. *amphisphenia.*—Dorsally acutely lanceolate, gradually attenuated towards the ends; umbilicus oblong, in which it differs from N. *fulva,* which has a round umbilicus.

N. *Bacillum.*—Smooth, linear dorsally and bacillar; ends rounded.

N. *biceps.*—Smaller than preceding, dorsally broadly lanceolate; apices rather constricted, but obtuse. Mexico and North America.

N. *carassius.*—Small, widely lanceolate on back; ends suddenly constricted, obtuse, but rather prolonged. Shorter and wider than N. *amphisbœna.* Surinam.

N. *dilatata.*—Large, dorsally elliptic-lanceolate, laterally rather convex, with longitudinal lines; ends obtuse.

N. *Dirhynchus.*—Small, dorsally narrowly lanceolate; ends elongated, rostrate, obtuse. Mexico, Labrador.

N. *dubia.*—Small, linear lanceolate on back; sides rather curved, the curve extending to the subacute prolonged ends. Surinam.

N. *duplicata.*—Oblong, small; constricted at the middle (panduriform); ends attenuate. Approaches *Pinnularia didyma.* Cuba.

NAVICULA *Formica.*—Oblong, linear dorsally; constricted in four places; segments oblong. Marine in United States.

N. *Fusidium.*—Large, narrowly lanceolate on back, slightly constricted at the ends, which are rounded and capitate.

N. *Hitchcockii*—Dorsally broadly linear, oblong; laterally constricted in two places, thus producing three equal projections; ends suddenly cuneate, subacute. Massachusetts.

N. *Iridis.*—Large, elongated, bacillar; sides plane; apices slightly attenuated, obtuse; surface very finely striated longitudinally, causing it to display various colours. If *sui generis* (?) New York.

N. *leptogongyla.*—Smooth, small, linear, slender; a central round protuberance on the back; ends obtuse, rounded, rather dilated. Thun and Labrador

N. *leptorhynchus.*—Small; dorsally, linear lanceolate; ends very long, rostrate, straight, subacute. Approaches N. *dirhyncus,* but ends longer rostrate. Mexico.

N. *limbata.*—Small, linear dorsally; sides straight; internally, as if widely bordered (*limbate*); apices suddenly constricted, but truncate. Chili.

N. *lineolata.*—Small; on dorsum narrowly lanceolate, with longitudinal fine lines; ends acute; on side widely linear. Length 1-288th. Fresh water.

N. *Lyra.*—Larger, broadly elliptic-lanceolate; ends constricted, obtuse; surface with a central double raised band, in the form of a lyre of two cords. Falkland Islands.

N. *mesolepta.*—Linear, elongate, undulate on back, slender; three undulations at the centre; ends much constricted, rostrate, obtuse. Length 1-420th.

N. *mesotyla.*—Smooth, narrowly linear laterally, slender on the back, with a central spherical enlargement; apices contracted, obtuse. Length 1-420th

N. *oblonga.*—Oblong-lanceolate and subacute, not produced (rostrate) Salt water. Length 1-720th. Mexico.

N. *obtusa.*—Small; oblong dorsally, and lanceolate; ends rounded, obtuse. Kützing thinks it probably identical with N. *appendiculata.* North America.

NAVICULA (?) *paradoxa*.—Large, quite smooth, widely oblong on back; slightly constricted at the middle; ends cuneate, obtuse; centre longitudinally dotted. Peru.

N. *Rhombea*.—Widely lanceolate on back, almost rhomboidal, with delicate longitudinal lines; ends acute. Length 1-480th to 1-360th. Mexico.

N. *Semen*.—Back ovate, turgid, ventricose at the centre, obtusely rounded at the ends. Variety (*a.*) Ends rather constricted—N. *Chilensis*. Var. (*b.*) Ends rounded—N. *Labrador*.

N. *Silicula*.—Smooth, linear, elongate, with three equal protuberances (nodes) on back; one at the centre, and one at either end, hence the ends obtuse. North America.

N. *Sphærophora*.—Lanceolate, ends produced (rostrate), capitate and papillate. Length 1-320th. In fresh water.

N. *Trabecula*.—Linear, elongate, with a single node at the centre, ends not contracted, and round. Kützing thinks it to be a variety of *Pinnularia decurrens*.

N. *nodosa*.—Small, broadly oblong on back, sides with three equal swellings; ends constricted, obtuse. Approaches N. *Hitchcockii*. North America.

N. (?) *omphalia*.—Large, with granular lines, which, from being very finely decussated, reflect various colours; umbilicus solid, round, clear, with the median suture passing through it. A large and elegant species. Fragments from Bermuda, 1-192nd in size.

N. *elliptica*.—Elliptic; ends imperfectly subacute; central umbiliary, subquadrate; three fine sutures; margin wide, very minutely dotted. Length 1-576th. Southern Ocean.

N. *Cantonensis*.—Broadly ovate, lanceolate, very smooth; ends acute, little produced. By its shorter acute ends it differs from N. *fulva*. Length 1-480th. Canton, China.

N. *Sinensis*. — Flexuose, sigmoid, larger than preceding, very smooth; ends widely rounded, expanded in the centre. Length 1-180th.

N. *tortuosa*.—Bacillar, smooth, rather turgid, and tortuose. Length 1-288th.

N. *decussata*.—Oblong-elliptic, strong, constricted at each end, as if obtusely mucronate; surface elegantly sculptured by decussating

dotted lines; the puncta arranged in a quincunx. Has the habit at of N. *amphisbæna.*

Navicula *leptostylus.* This fossil species, and the seven following, were discovered by Ehrenberg in earth from Ireland.

N. *Cocconeis.*

N. *Amphirrina.*

N. *osculata.*

N. *birostris.* Probably *Stauroneis birostris.*

N. *Stylus.*

N. *amphiata.*

N. *mesopachya.*

N. *diaphana.*—Large, elongate, lanceolate; apices obtuse; surface very smooth, diaphanous; umbilicus not perforating; a double longitudinal line down the centre. Habit of *Stauroneis Phœnicenteron.* (1-192nd.)

N. *Demeraræ.*—Smaller; oblong and smooth; ventrally, rhomboid, and tumid; apices acute, attenuate, and subrostrate. Length 1-576th.

N. *Schomburgkorum.*—Large, elongate, lanceolate, with obtuse extremities, and the habit of N. *diaphana*, but with three longitudinal lines (sulci) on each side the umbilicus. Length 1-180th. Alive in Guiana.

Nägeli describes (Report Ray Society, 1846, p. 221,) what he assumes to be a new species of *Navicula*, nearly allied to *Navicula striata* (Ehr.) = *Surirella Striatula* (?). He found it in brooks about Zurich; it exhibits no movement. The contained matter is brown, and fills the whole of the central cavity, except the horns (prolonged extremities), which are transparent and uncoloured.

Nägeli adduces this species as illustrating the existence of a nucleus and nucleolus in the interior; and it is in it also that he "observed a pretty rapid circulation of the granular contents, the granules passing from the nucleus outwards, along the edges, and back again to the former."

Kützing divides his genus *Navicula* into six sections; it includes numerous species of the genus *Pinnularia*, as that naturalist does not recognize the presence or absence of transverse striæ as a generic distinction. In his recent volume, "Species Algarum," he enumerates 179 species, including nine doubtful; most of them are de-

scribed herein under one or other of the sub-genera. The sections herein remain the same, viz. —

a.—Form lanceolate, eighty species.

b.—Form oblong or elliptic, twenty-nine species.

c.—Form gibbous, sixteen species.

d.—Form constricted or nodose, thirty species.

e.—Form lunate, two species.

f.—Form sigmoid, thirteen species.

Sub-genus PINNULARIA.— Umbilicus round; surface transversely striated.

P. *viridis.*—Lorica transversely striated; straight, lanceolate, oblong; obtuse and truncate at the ends; striæ fifteen in 1-1200th. Common, living and fossil. Figs. 133 and 134 represent living, and figs. 135 and 136 fossil forms. (P. 15, f. 15 and 31); the arrows in the two first figures indicating the direction of the current produced. Length 1-1150th to 1-70th. In the interior, numerous changeable vesicles are seen, connected together by means of an irritable gelatinous matter, which is as clear as crystal, and from whose motion these globules often appear to tremble. Ehrenberg has noticed moveable dark spots near the extremity of some specimens, similar to what is seen in *Closterium,* &c. The progress of longitudinal self-division may often be observed beneath the siliceous lorica. The six openings of the lorica are easily seen, three being upon the upper surface and three on the lower. The lorica near the central opening being depressed, the aperture appears eccentric, in respect to the medial line. Found at Hampstead, and fossil in Bohemia, Sweden, &c.

P. *inequalis.*—Striated and unequally convex (see group 154.); of a yellowish colour. In 1-100th of a line are ten or eleven striæ. This species forms the passage to the genus *Eunotia.* Found living, at Tilbury Fort and elsewhere; also fossil at San Fiore. Length 1-430th to 1-120th. The unequal sides in this species would render it, in Kützing's classification, a member of the genus *Cymbella.*

P. *macilenta.*—Slender, elongated, attenuated towards the obtuse rounded extremities; striæ twenty-three in 1-1200th; strong, oblique, and converging to the centre. Fresh water and fossil. Length 1-140th.

PINNULARIA *capitata.*—Short, ovate, lanceolate, ventricose at the centre; ends constricted and obtuse; striæ ten in 1-1200th. Length 1-1150th to 1-576th.

P. *dicephala.*—Linear, elongate, constricted, and obtuse at each end, which consequently appears capitate; striæ nineteen in 1-1200th. Length 1-860th to 1-480th. Fossil in North and South America, and Sweden.

P. *lanceolata.*—Lanceolate, elongate, tapering from the turgid centre to the acute extremities; both longitudinal and transverse stripes, thirteen of the latter in 1-1200th. Length 1-1150th to 1-280th.

P. *viridula.*—Straight, lanceolate, slender, one end truncate, the other attenuate and obtuse; striæ thirteen to fifteen in 1-1200th. Length 1 3000th to 1-280th. Alive and fossil.

P. *didyma.*—Striated, rather broad; viewed from the side, linear; truncated at both ends, and entire; viewed dorsally, constricted in the middle; ends sub-orbicular; it thus appears as if formed of two discs joined together. Twenty-three striæ in 1-1200th. Fossil in the chalk marl of Caltanisetta, living in sea water. This species was first observed alive, afterwards fossil, in Sicily. Similar forms are very numerous in the chalk marl of Greece. It is distinguished from P. *entomon* by the want of the constriction when viewed on the lateral surface; ventral surface with a central colourless stripe. Length 1-1150th to 1-480th. (P. 24, f. 12.)

P. *Norvegica.*—Laterally linear, narrow, and truncated at both ends, dorsally broadly ovate, and acute at the extremities; circumference with a narrowly striated margin, area smooth; thirty striæ in 1-1200th. The N. *praetexta*, of the Greek chalk marl, is very similar to this species. Length 1-360th.

P. *quadrifasciata.*—Laterally narrow, linear, truncate; dorsally broadly ovate, ends acute, margin wide; a double longitudinal narrow striated band on each half; hence it is apparently marked by four stripes or bands, whence the name. Striæ twenty in 1-1200th. Alive in the Baltic. Fossil in the chalk marl of Greece. In the living state it is of a greenish or rusty yellow colour. Length 1-430th.

P. *æqualis.*—Large, lanceolate, oblong, ends constricted, obtuse; sides even, minutely pinnate. Iceland.

PINNULARIA *amphigomphus.* — Larger, oblong dorsally, sides plane, ends acutely wedge-shape; it is remarkable by indistinct longitudinal lines; approaches *Navicula amphigomphus.*

P. *amphioxys.* — Narrow, linear lanceolate, acute; sides with straight pinnules. New York and Iceland.

P. *amphiprora.*—Larger on back, narrowly lanceolate, ends broad, obtuse; it has the habit of *Amphiprora Navicula,* but with marginal apertures at the extremities. Massachusetts.

P. *Apis.*—Oblong on the back, and so much constricted at the centre, as to be nearly divided into two sub-orbicular segments; ends obtuse, pinnules rough (granules), and twelve in 1-1200th. Vera Cruz.

P. *borealis.*—Striated, small, laterally linear, ends rounded, but not constricted; pinnules strong. Has the habit of *Fragilaria pinnata.* Chili, New York.

P. *chilensis.*—Larger, oblong, straight to the sides; ends broadly rounded, not constricted; pinnules strong, and eleven to twelve in 1-1200th; approaches P. *viridis,* but is shorter and broader. Chili. (P. 15, f. 33.)

P. (?) *Conops.* — Oblong on back; divided into two cordate parts by a central constriction; ends apiculate; pinnules very minute. Vera Cruz.

P. *costata.* — Large, thick, short, ovate, oblong; ends widely rounded; pinnules large, prominently costate, six in 1-1200th; approaches P. *Dactylus.* North America.

P. *Cyprianus.*—Oblong-lanceolate, ends widely rounded, umbilicus oblong. Chili.

P. *Dactylus.*—Long, bacillar, straight laterally; dorsally very slightly curved towards the extremities, which are broadly rounded; pinnules fourteen in 1-1200th. North America.

P. *decurrens.* — Striated, narrow, elongate, lanceolate; dorsally broad, and tumid at centre, somewhat narrowing towards the extremities, which are however widely rounded; approaches P. *gibba* and = P. *Trabecula,* a smaller variety.

P. *diomphala.*—Short, broadly lanceolate on back, ends constricted,

obtusely truncate; central umbilicus transverse, and divided by a longitudinal line into two parts. Mexico.

PINNULARIA *disphenia.*—Striated, linear, elongated dorsally, sides straight; ends acutely wedge-shaped; pinnules of margin very minute; approaches P. *amphigomphus.*

P. *Entomon.*—Larger, elongate, widely constricted at centre, (panduriform) presenting two oblong portions with cuneate extremities, subacute; striæ smooth, not granular; broad, nineteen to twenty in 1-1200th. Alive and fossil.

P. *Esox.*—Large, elongate; narrowly lanceolate, dorsally, slightly undulate on the sides; three undulations on each side, of which the central one is the most marked. Extremities very attenuate, but obtuse. (P. 15, f. 43.) Chili.

P. *Gastrum.*—Striated, small; underside widely lanceolate; ends constricted, but little produced, and obtuse, with granular eminences. Mexico.

P. *Gigas.*—Very large, wand-shaped, slightly gibbous at centre of dorsum, gently diminishing towards extremities, which are rounded; nine pinnules (striæ) in 1-1200th; approaches P. *nobilis.* North America

P. *heteropleura.*—Broadly lanceolate on the back; sides unequal; ends slightly constricted and broadly obtuse. Is near P. *inæqualis,* the ends of which are however sub-acute.

P. *isocephala.*—Linear on back, undulate, with five eminences (nodules) produced by as many constrictions, somewhat of unequal size; whence it has a moniliform outline. Scarcely differs from P. *Monile* which is larger.

P. *macilenta,*—Bacillar dorsally; sides straight; ends rounded, wide; pinnules narrower and closer than in preceding, there being eighteen to twenty in 1-1200th. This species = P. *polyptera,* which is probably but a more slender variety.

P. *mæsogongyla.*—Striated, styliform, and bacillar; gibbous at the middle dorsally; ends rounded, wide, not turgid; near P. *nobilis.*

P. *monile.*—Very small; striated dorsally, constricted so as to form five equal sub-globose segments; viewed on the sides, it is linear and truncate. Approaches *Navicula nodosa,* Length 1-864th.

Pinnularia *nobilis*.—Very large, striated, of an elongated, quadrangular, bacillar figure; turgid at the centre, and slightly so at the extremities. Length 1-84th. Pinnules sixteen to eighteen in 1-1200th. Fossil in South America. Terminal apertures very large. San Fiore, Cayenne, Brazil.

P. *pachyptera*.—Striated, large, oblong, bacillar, but short and thick; gibbous in centre of dorsum broadly rounded, not constricted at extremities. Pinnules very strong, six in 1-1200th. Labrador.

P. *peregrina*.—Striated, linear lanceolate, narrow, ends gradually tapering, acute, not constricted; pinnules oblique. St. Domingo, Cuba, New York.

P. *pisciculus*.—Striated, very delicate; narrowly linear; ends constricted, prolonged, rostrate, and sub-capitate. Approaches P. *dicephala*. Cayenne.

P. *placentula*.—Small, very broadly lanceolate, oblong, ends constricted, obtuse, rather produced, papillary; near P. *gastrum*, but larger. Vera Cruz, Mexico.

P. *porrecta*.—Striated, larger; lanceolate, elongate dorsally, widely expanded at the centre; ends gradually attenuate, but broadly obtuse; pinnules oblique. Is near to P. *decurrens*. Central and North America.

P. *praetexta*.—Large, elliptic; margins on the dorsal aspect expanded, furnished with very broad pinnules, whilst the intermediate space (median area) is granular; striæ seventeen in 1-1200th. Length 1-288th. Fossil in Greek marl.

P. *Sillimanorum*.—Striated; large, lanceolate dorsally; widely expanded at middle or ventral surface, oblong; ends constricted, produced, obtuse, and sub-capitate. Approaches *Diomphalus Clarae Herculis*. New York.

P. *sinuosa*.—Small, narrow, linear lanceolate, sigmoid; striæ fifteen in 1-1200th. Mouth of the Elbe. Has the figure of *Navicula sigma*, but is more slender.

P. *Tabellaria*.—Bacillar, slender, of three segments (Trinodal) being turgid at centre, and having capitate extremities. Is more slender than P. *nobilis*, which it about equals in length. Central and North America. (P. 15, f. 21.)

PINNULARIA *Termes.*—Striated, small, narrow, oblong, rather constricted at the centre, and towards each end; the ends obtuse, widely rounded, and produced.

P. *Utriculus.*—Striated, oblong dorsally, sides straight, slightly curving towards the ends, which are tapering but obtuse. Approaches P. *disphenia.* Mexico.

P. *caraccana.*—A variety of P. *borealis,* larger and more dilated at the middle. Length 1-480th.

P. *oceanica.*—Elliptic-oblong; its length twice its breadth, ends subacute; umbilicus small, round, clearly defined; suture double, margin very delicately but widely pinnate; pinnules twenty in 1-1200th. Length 1-570th. Southern Ocean.

P. *lamprocampa.*—Very large, sigmoid, slender, lanceolate; very delicate striæ on margin; apices subacute. Length 1-144th. Pinnules are visible in the dry state, but not in the living. It is very mobile. Baltic and Falaise.

P. *libyca.*—Striated, small; dorsally navicular, ovate-lanceolate, acute; laterally quadrangular and truncate; pinnules fourteen in 1-1200th. Habit of *Navicula fulva,* but is wider and not rostrate. Length 1-550th. Oasis, Sinai.

P. *Kefringensis.*—Striated, small, lanceolate, and navicular dorsally; pinnules converging towards the centre, and seventeen in 1-1200th. Length 1-430th.; very close to P. *viridula,* but more slender.

P. (?) *thermalis.*—Small linear; cuneate and acute dorsally; laterally truncate. Length 1-576th. In warm springs. Habit of *Fragilaria acuta*; umbilicus unknown.

P. *Furcula.* — Small, dorsally elliptic; oblong on both sides, linear; apices constricted, umbonate (bossed); pinnules converging to the centre. Length 1-864th. to 1-720th. Fossil.

P. *Gemina.*—Small, divided by a constriction, existing on each aspect, into two lenticular segments; remarkable by a central spine; *(apiculus)* when seen on the side. Length 1-840th. to 1-648th.

P. *Seminulum.* — Found by Ehrenberg in the plastic marl of Ægina.

P. *coarctata.*—The same habitat.

PINNULARIA *contracta.*—The same habitat.

P. *tæniata.*—Small, on dorsal aspect, umbilicus distinct; pinnules, marginal, strong, ends suddenly constricted, prolonged, rounded, and obtuse. (P. 24, f. 15.)

P. *Australis*, P. *pleuronectes*, and P. *styliformis*, new species discovered by Ehrenberg in earth from New Holland.

P. *amphistylus.*—Bacillar, elongate, turgid at the middle; apices attenuate, filiform, obtuse; pinnules fine. Length 1-372nd. Fossil in Oregon.

P. *leptostigma.*—Oblong-lanceolate, length twice its breadth; apices subacute, rather produced; very fine transverse dotted lines, (pinnules) inconspicuous. Length 1-432nd. Fossil.

P. *Oregonica.* — Elongate, navicular, bacillar, uniformly and gradually decreasing towards the rounded apices; pinnules strong, twenty-three in 1-1152nd. Length 1-228th. Fossil in Oregon. It approaches P. *Digitum*, but is more slender.

P. *Schomburgkii.* — Large, lanceolate, equal, length thrice its breadth; apices subacute; pinnules twenty-five in 1-1152nd.; approaches P. *æqualis*, but is smaller and more obtuse. Length 1-264th. Guana. Alive.

P. *Couperii* (Bailey.)—Large, slightly constricted in the middle, with two marginal and two intermediate punctato-striate bands, the latter interrupted at the centre. The outline is like that of P. *paradoxa* (Ehr.), and the markings somewhat resemble those of P. *lyra.* Southern States of America.

P. *permagna* (Bailey.)—Large, lanceolate on the ventral surfaces, with punctato-striate marginal bands; and a broad, smooth, central stripe; ends slightly rounded. Abundant in the Hudson River, at West Point, New York.

P. *æquinoctialis* (Montagne.)—Rather large, linear-oblong, apices rounded, pinnules radiant, strong, four in 1-2600th. Length of frustule 1-260th. to 1-150th. Found with Algæ in British Guiana. It, in general form, resembles P. *Dactylus*, but differs in its size and larger striæ. In the last particular it resembles P. *pachyptera*, but that species has a median dilatation or gibbosity. Montagne, in his notice of the cryptogamic plants of Guiana, (Ann. de. sc. Nat. vol.

14, 1850, p. 308), has described this species as a *Navicula,* but the transverse striæ determine it to be a *Pinnularia* in Ehrenberg's plan.

Sub-genus DIPLONEIS.—The three following species have been described by Ehrenberg under the name of *Diploneis,* by which appellation it would seem he wishes to designate a sub-section of *Pinnularia,* having some distinguishing peculiarity, which, however, has not been met with in his writings.

From the figure of *Diploneis Didyma,* it may be presumed that Ehrenberg intends this sub-genus to include *Pinnularia,* constricted at the middle, in the dorsal and ventral aspect, and having, so to speak, a double (*diplos* Gr.) outline.

D. *Bombus.*—Constricted, with sub-cordate segments; apices subacute; striæ dense, granular, twenty-one in 1-1200th.; granules of the largest striæ in fours. Length 1-384th. Fossil in the chalk marl of Ægina.

D. *crabro.*—Constricted, with widely separated elongate lanceolate lobes, subacute or obtuse; striæ strong but smooth; eleven to twelve in 1-1200th. Length 1-276th. In chalk marl from Ægina.

D. *Didyma.* = *Pinnularia Didyma.* (P. 24, f. 12.)

Sub-genus STAURONEIS (Ehr.)—Lorica smooth, or longitudinally striped; median aperture (umbilicus) transverse; but no transverse striæ.

Under this name Kützing includes all *Naviculæ* with a transverse median aperture, whether striated transversely or not.

S. *Phoenicenteron* (*Cymbella,* Agardh.)—Smooth, of an elongated lanceolate form, with rather obtuse tapering ends; longitudinal striæ rare. It is very motile. Ponds, Hampstead; and fossil at San Fiore, in Tuscany. Length 1-400th. to 1-140th. (P. 3, f. 139, and p. 15, f. 17 and 18.)

S. *platystoma.*—Smooth, linear lanceolate, apices produced, widely truncate; central opening transverse. (fig. 142.) Length 1-1100th. to 1-240th.

S. *amphilepta.*—Narrowly lanceolate, ends constricted, sub-capitate, rounded. Chili.

S. *anceps.*—Smaller than preceding; narrow, linear lanceolate ends constricted, sub-capitate, and truncate. Cayenne.

STAURONEIS *Baileyi.*—Broadly lanceolate, tapering gradually to the ends, which are obtuse. Surface with very fine undulating longitudinal lines; approaches S. *pteroidea* and S. *Phoenicenteron.* North America.

S. *birostris.*—Smaller, narrowly lanceolate, ends produced, rostrate, subacute. Surinam, Mexico.

S. (?) *constricta.*—Small; oblong; constricted at the centre, and at the ends, which are much produced and obtuse. Chili.

S. *dilatata.*—Small, broadly oblong on ventral aspect; laterally straighter; ends constricted, obtuse, broadly and briefly rostrate. Mexico, Chili. (P. 15, f. 16.)

S. *fenestra.*—Elliptic-oblong, with obtuse cuneate extremities; quite smooth at centre, but with marginal parallel lines. Cayenne.

S. *gracilis.*—Slender; linear, lanceolate; ends tapering, truncate. North and South America.

S. *linealis.*—Narrowly linear, oblong, ends tapering, obtuse, produced, and rostrate; parallel lines on the margin. Length 1-720th. Trinidad, Nordhausen.

S. *lineolata.*—Lanceolate, with dotted longitudinal lines; ends tapering, subacute. Cayenne.

S. *Liostauron.*—Styliform, slightly turgid at centre, extremities but slightly tapering and rounded. Iceland.

S. *Monogramma.*—Oblong, turgid at centre; ends constricted, enlarged, rounded, sub-capitate. Surinam.

S. *Polygramma.*—Lanceolate, with dotted lines, decreasing towards the ends, which are rounded and obtuse; central umbilicus expanded transversely. Cuba.

S. *Phyllodes.*—Widely lanceolate or elliptic, smooth; ends much contracted, rostrate, subacute. (P. 15, f. 7, 8 and 9.) South America.

S. (?) *pteroidea.*—Large; broadly and acutely lanceolate, with very minute dotted transverse lines, as if pinnulate; ends obtuse; approaches S. *Baileyi.* If a *Stauroptera.* (?) North America.

S. *Staurophæna.*—Lanceolate, smooth, slightly constricted at the extremities, which are subacute. The central transverse umbilical band not very distinct. Approaches S. *Phoenicenteron.* North America.

STAURONEIS *Sigma*.—Has the form and size of *Navicula Sigma*, but with an apparent double central expanded umbilicus. Length 1-240th. Richmond, Virginia.

S. *augusta*.—Discovered by Ehrenberg, in earth from Siberia.

S. *Atlantica*.—Small; lanceolate dorsally, with obtuse apices; linear laterally. Approaches S. *amphileptus*. Var. of S. *amphileptus* of Chili; more obtuse. Length 1-1152nd. In pumice from the Island of Ascension.

S. *lanceolata*, (Kütz.)—Slender, lanceolate, with subacute apices, which are also rather produced and acuminate. Length 1-180th to 1-160th. Falaise.

S. *exilis*. — Very small, elliptic-lanceolate; shortly rostrate. Length 1-2400th. In fresh-water, Trinidad.

S. *amphicephala*.—Linear-oblong, apices produced, rostrate and capitate. Nordhausen.

S. *inflata*. — Oblong, widely expanded at the centre, and the two ends thus having two constrictions; ends widely rounded, truncate. Length 1-480th to 1-428th. Trinidad.

S. *ventricosa*.—Very small, especially in the middle, and inflated; capitate twice constricted; umbilicus transverse. Length 1-1320th. Nordhausen.

S. *pumila*.—Elliptic-lanceolate, acute, margin punctate, striate; laterally oblong, widely truncate. Length 1-1440th to 1-1080th. Christiana.

Kützing does not make a generic distinction between *Stauroneis* and *Stauroptera*; hence the present, and the following species, derived from his great work, are, as understood by Ehrenberg, *Stauroptera*.

S. *Achnanthes* = *Stauroptera Achnanthes* (Ehr.)

S. *aspera* = *Stauroptera aspera* (Ehr.)

S. *Isostauron* = *Stauroptera isostauron* (Ehr.)

S. *parva* = *Stauroptera parva* (Ehr.)

S. *scalaris* = *Stauroptera scalaris* (Ehr.)

S. *punctata*.—Small, broadly lanceolate, apices produced, rostrate; transverse striæ punctate Fossil, San Fiore.

S. *microstauron* = *Stauroptera microstauron* Ehr.)

S. (?) *gibba* = *Stauroptera* (?) *gibba* (Ehr,)

S. *Legumen* = *Stauroptera Legumen* (Ehr.)

STAURONEIS *maculata* (Bailey.) — Lanceolate or elliptical, end slightly produced and rounded; surface punctato-striate, with a large smooth central space. Resembles S. *punctata* of Kützing, but is larger, and has the ends not so much produced. Florida

Sub-genus STAUROPTERA.—Lorica transversely striated; median aperture (umbilicus) transverse.

S. *aspera.*—Hexangular; laterally quadrangular; dorsally navicular; keeled; with transverse granular striæ. Length 1-216th. Living, Christiania.

S. *cardinalis.* — Large, bacillar, quadrangular, extremities not attenuated, but simply rounded; striated on the sides, transversely. Length 1-180th.; often sixteen times greater than the breadth. (P. 15, f. 72.) Fossil, South America, San Fiore, &c.

S. *capitata.*—Very small, oblong; its length twice its breadth; viewed on the back (dorsally) linear; ventrally, constricted suddenly at each end and capitate; apices rather dilated. It has eighteen striæ in 1-1560th. Length 1-1152nd. Southern Ocean.

S. *granulata.*—Figure bacillar, but turgid at middle; ends obtuse; surface with transverse granular striæ. Length 1-480th. Canton, China. Allied to *Fragilaria* (?) *mesotyla*, and to *Achnanthes ventricosa.*

S. *semicruciata.*—Very large; resembles *Pinnularia viridis*, but has the crucial umbilicus, characteristic of this sub-genus.

S. *leptocephala.*—A new species discovered by Ehrenberg in earth from New Holland.

S. *Achnanthes.*—Narrowly lanceolate; ends tapering, subacute. Mexico, Newfoundland..

S. (?) *gibba.*—Has the form of *Eunotia gibba;* but is characterized by its imperfect transverse umbilical band. It is, however, a doubtful form. Chili.

S. *Isostauron.*—Styliform on its ventral aspect; laterally straight; ends slightly decreasing, and widely rounded. Approaches S. *cardinalis.* Labrador. (P. 15, f. 73.)

S. *Legumen.*—Oblong, small; dilated ventrally; laterally with three undulations; extremities constricted, obtuse. Berlin, Chili, Cayenne.

STAUROPTERA *microstauron.*—Styliform and linear on ventral surface; sides straight; suddenly and sharply constricted, with wide, obtuse, rounded apices. Brazil, Labrador.

S. *parva.*—Small, styliform, and linear; on ventral surface with marginal lines, sides not quite straight; ends rather constricted and widely rounded. Mexico.

S. *scalaris.*—Very small; bacillar on under surface; straight, viewed laterally; ends rounded, pinnules strong, and twelve in 1-1200th. Labrador. (P. 15, f. 10, 14, and 30.)

S. *dendrobates.*—Ventrally, narrowly linear; ends obtuse; border finely and obliquely striated; on lateral aspect broadly oblong, quadrate. Length 1-490th. Has been seen divide longitudinally.

Sub-genus PLEUROSIGMA (Smith.)—Valves convex, sigmoid, striated; striæ resolvable into dots.

This genus, so characterised, comprises several members of Ehrenberg's sub-genera *Navicula* and *Ceratoneis*, and would probably embrace, also, some of the *Stauroptera.*

The shells of the different species of this sub-genus, are much employed as tests for microscopes. To exhibit the striæ, requires oblique illumination, and an object-glass of large angular aperture.

* Beads alternate, striæ oblique; all marine.

P. *formosum.*—Valve linear lanceolate, gradually attenuated to the somewhat obtuse ends, twisted; median line broad, not central; colour bright chestnut-brown. Length 1-66th. Greatest breadth 1-850th. Oblique striæ 1-3000th inch apart. Shoreham Harbour. This species is well distinguished by the position of its median line, which, owing to a twist in the valves, appears nearly to coincide with the edges for a considerable distance at either end, and then crosses in a diagonal direction (P. 19, f. 1 and 2; the latter a portion magnified 5500 diameters.)

P. *speciosum.*—Valve linear, slightly attenuated, somewhat twisted, extremities obtuse, median line not central; colour a pale straw. Length 1-85th. Greatest breadth 1-850th. Striæ 1-40,000th apart. It is straighter, stouter, and more delicately marked than the former. (P. 19, f. 3.)

P. *elongatum.*—Valve linear lanceolate; flexure slight, extremities

acute, median line central; colour a clear straw. Length 1-75th. Breadth 1-920th. Striæ 1-44,000th apart. Poole Bay, Lewes, and Hull. (P. 19, f. 4.)

PLEUROSIGMA *delicatulum.*—Valve narrow, lanceolate; flexure slight, extremities acute; colour very pale straw, with a slight tinge of pink. Length 1-112th. Breadth 1-1500th. Striæ 1-50,000th apart. More delicate than the last; striæ very indistinct (P. 19, f. 5.) Lewes.

P. *strigosum.*—Valve lanceolate, flexure slight, extremities obtuse, colour straw. Length 1-90th. Breadth 1-800th. Striæ 1-38,000th apart. Coast of Sussex, Hull, &c. (P. 19, f. 6.)

P. *angulatum.*—Valve broadly lanceolate or quadrangular, extremities acute, flexure moderate; colour a bright chestnut. Length 1-110th, Breadth 1-428th. Striæ 1-45,000th apart. (P. 19, f. 7.)

Var. *(b.)*—Valve narrow, lanceolate, slightly quadrangular (P. 19, f. 8) = *Navicula Æstuarii* (Kütz.) 1849.

Var *(c.)*—Valve much smaller, quadrangular (P. 19, f. 9)

"The quadrangular form of this species is always more or less present, and seems to distinguish it from all its allies."

P. *distortum.*—Valve lanceolate, abruptly bent towards the obtuse extremities; colour a very pale pink; striæ obscure. Length 1-320th. Breadth 1-1500th. Coast of Sussex. Probably the young of some other species (P. 19, f. 10.)

P. *obscurum.*—Valve linear, slightly attenuated towards the obtuse extremities; median line not central; colour very pale pink; striæ obscure. Length 1-193rd. Breadth 1-2000th (P. 19, f. 11.) Poole Bay and Lewes.

Var. *(b)* much smaller, more gradually attenuated (P. 19, f. 12.) Poole Bay, covering a sponge.

* * *Beads opposite; striæ transverse and longitudinal; all marine.*

P. *Balticum.*—Valve linear, straight, suddenly attenuated towards the sigmoid extremities, which are somewhat obtuse; colour dark brown. Length 1-83rd. Breadth 1-850th. Striæ 1-38,000th apart. (P. 20, f. 1 and 17.)

Var. *(b.)*—Smaller, gradually attenuated (P. 20, f. 2,)

Var. *(y.)*—Much smaller, attenuated throughout; striæ obscure (P. 20, f. 3.

This species = *Navicula Baltica* (Ehr.) 1838.—It is distinguished by the parallelism of its sides, and the great convexity of its valves.

Pleurosigma *Strigilis.*—Valve lanceolate, uniformly attenuated towards the somewhat acute extremities; colour paler than the last. Length 1-80th. Breadth 1-830th. Transverse striæ 1-33,000th apart. Hull. Notable for its graceful form and distinct striæ (P. 20, f. 4.)

P. *acuminatum.*—Valve broadly lanceolate, much attenuated towards the extremities; colour a light brown. Length 1-162nd. Breadth 1-1200th. Striæ 1-45,000th apart. It = *Navicula sigma* (Ehr.) 1838. Shoreham Harbour. (P. 20, f. 5.)

P. *Fasciola* = (*Ceratoneis Fasciola*, Ehr.)—Valve lanceolate, extremities produced, flexure considerable; colour very pale. Length 1-240th. Breadth 1-1847th. Striæ 1-55,000th apart. On the mud of tidal harbours (P. 20, f. 6.)

"I have restored this species to its allies, the elongation of its valves not appearing to require its separation, and the more careful examination of its surface showing the central and terminal enlargements of its median line, characteristic of the true *Naviculeæ.*"

P. *prolongatum.*—Valve much elongated, very narrow, lanceolate; flexure moderate; striæ obscure; colour very pale. Length 1-162nd Breadth 1-2400th. Striæ imperceptible (P. 20, f. 7.) Poole Bay.

P. *littorale.*—Valve broadly lanceolate, acute; flexure considerable; longitudinal striæ very distinct; colour blueish-grey. Length 1-200th. Breadth 1-1200th. Longitudinal striæ 1-18,000th apart (P. 20, f. 8, and fig. 19 magnified 5500 diameters.) Coast of Sussex.

P. *Hippocampus* = *Navicula Hippocampus* (Ehr.) 1838.—Valve broadly lanceolate, obtuse; flexure considerable; striæ distinct; colour pale brown. Length 1-166th. Breadth 1-1100th. Striæ 1-36,000th apart (P. 20, f. 9, and fig. 10, a young state.) On muddy shores and brackish pools.

"The specific name of this species has been given to almost every sigmoid *Navicula*, whether found in the sea or fresh water, by non-scientific observers;" but Mr. Smith would restrict it to the present, although probably the next species was the one to which Ehrenberg originally attached the name. He is also "disposed to believe the

two species have been frequently confounded, but their habitats are quite distinct, the present being marine, the next freshwater; the *Hippocampus*, too, is a shorter and stouter species, and its striæ more delicate."

b. Freshwater species.

PLEUROSIGMA *attenuatum* = *Navicula Hippocampus* (Ehr. ?)—Valve elongated, lanceolate, obtuse; flexure moderate; striæ very distinct; colour purplish-brown. Length 1-120th. Breadth 1-1000th. Longitudinal striæ 1-25,000th apart. Transverse striæ 1-40,000th (P. 20, f. 11; fig. 12 a young specimen; fig. 13 a front view, showing self-division; fig. 18 a portion of fig. 11, magnified 3200 diameters.) Common in streams and ditches.

P. *lacustre.*—Valve lanceolate, much attenuated towards the acute extremities; colour pale brown. Length 1-144th. Breadth 1-1100th. Longitudinal transverse striæ 1-45,000th apart (P. 20, f. 14.)

P. *Spencerii.* — Valve lanceolate, slightly attenuated, obtuse; flexure slight; colour very pale brown. Length 1-270th. Breadth 1-2000th. Striæ 1-50,000th apart. Not uncommon in ditches.

Genus ODONTIDIUM.—(de Brébisson.)—Frustules quadrangular on secondary side, transversally, striated, lanceolate; closely conjoined in a biconvex band.

Ehrenberg has described the forms belonging to this genus, some among *Fragilaria*, others with *Bacillaria (Diatoma.)*

Odontidium belongs to the family *Fragilarieæ*, and exhibits an alliance with *Himantidium*, *Diadesmis*, and also with *Meridion.* The concatenation of the frustules, so as to form a band or filament, is well marked in the present genus. Its forms are most common in cold alpine springs.

O. *mesodon* = *Fragilaria mesodon* (Ehr.)—(P. 16, f. 24.)

O. *turgidulum* = *Fragilaria turgidula* (Ehr.)—(P. 16, f. 25.)

O. *glaciale.* — Filaments short and generally curved; segments mostly trapezoid, margin with many dentations; on secondary side elliptic-oblong, rather obtuse; striæ five to six in 1-1200th. Among Confervæ, Glacier of the Rhone.

O. *hyemale* = *Fragilaria striata* (Ehr.) and F. *hyemalis* (Ralfs.)

O. *pinnatum* = *Fragilaria pinnata* (Ehr.)

Genus ODONTODISCUS, (Ehr.)—Lorica simple, of two equal orbicular valves; lenticular in figure, not concatenated, without apertures and septa; valves furnished with dotted rays, the number of which is determinate, not cellular; but remarkable in having erect denticles (spines) on their surface.

Odontodisci differ from *Actinocycli,* to which they are most akin, by their valves being armed with teeth, of which the latter are destitute.

O. *eccentricus.*—Granules of disc disposed in eccentric curved rows, indistinctly radiating; granules about twenty in 1-1152nd; mostly with twenty-eight closely-set teeth on the margin. Diameter 1-864th. Fossil in Peruvian guano.

O. *Spica.*—With forty-eight rays and denticles near the margin of the disc, and nineteen granules in 1-1152nd. Fossil in Virginia.

O. *Uranus.*—The disc with thirty-two marginal rays and denticles, and nineteen granules in 1-1152nd. Fossil in Virginia.

Genus OMPHALOPELTA, (Ehr.)—Lorica simple, of two equal valves, orbicular, not in chains (?); divided internally into cells by imperfect radiating septa, which alternate with depressions on the exterior; centre smooth, apertures obsolete; spines erect, scattered, opposite, and placed on the upper margin of each side. Habit of *Actinoptychus* and *Heliopelta;* differs from the former by its lateral spines; from the latter, by the spines on its upper margin being scattered (*rarus.*) The number of rays, the figure, and the cells, often assimilate in these three genera; but the character of the spines constantly differs in them severally. These spines, moreover, by persisting after spontaneous fission, indicate the singular binary conjunction of individuals in the young state.

All the species approach, in form, *Actinoptychus senarius,* which is common in the North Sea, where they are never present.

O. *areolata.*—With six septa and rays; radiating areæ loosely, obscurely, but uniformly cellular, and but little or not at all depressed; rays distinct, margin radiate, wide, a single spine on the upper margin of each area of the disc. Diameter 1-300th. Fossil, Bermuda.

O. *cellulosa.*—With six septa and rays; the alternating cellular areæ

with tumid cells; puncta depressed, rays rather prominent, spines solitary on the centre of the upper margin of each area. Diameter 1-192nd. Fossil in Bermuda. Habit of *Actinoptychus senarius*, and of *Heliopelta Metius*.

OMPHALOPELTA (?) *punctata.*—With six rays and septa; radiating areæ, all loosely dotted; three alternate ones rather more prominent; margin slender, not clearly radiate, spines obsolete. If an *Actinoptychus?* Diameter 1-720th. Bermuda.

O. *versicolor.*—With six septa and rays; all the radiating areæ marked by very fine decussating and granular lines, whence it displays various colours, changing from brown to red; rays strong; umbilicus hexagonal, crystalline; margin slender, radiate; spines single, in the centre of the upper margin of each area. Diameter sometimes 1-252nd. Mostly smaller. Bermuda.

Genus PERIPTERA, (Ehr.)—Lorica simple, compressed, unequally bivalve; testa covering the valves, simple, continuous and not cellular (areolar); one valve turgid and naked (unarmed,) the other winged or horned; horns affixed to the extreme margin, sometimes branching. Approaches very near to *Rhizoselenia* and *Dicladia;* but the former has one exserted median horn, the latter two. From *Hercotheca* it differs by its compressed form.

P. *Capra.*—Smooth, one end with two simple horns, the other unidentate, or imperfectly bidentate (sub-bidentate); intermediate part with narrow transverse lines. Diameter 1-1440th. Virginia.

P. *Cervus.*—Smooth, larger, with long branching frontal horns. Diameter 1-576th. Maryland.

P. *chlamidophora.*—Smooth, compressed, almost navicular; one valve on the side plane, and extended by a finely-veined membrane; the other naked, turgid at the centre. Length 1-2304th. Width with the membrane (a compressed tubule) 1-1152nd. Bermuda.

P. *tetracladia.*—Smooth, compressed, almost navicular; one valve with four equi-distant setæ, branched at the apex; the other simple. Diameter 1-1440th; with setæ, 1-864th; without setæ, resembles *Amphora.* Bermuda.

Genus POROCYCLIA (Ehr.)—Cylindrical, lorica simple, utricular, truncate; each utricle spontaneously divisible through its middle, with apertures or minute pits on the margin of the smooth disc; concatenation

doubtful. Its inner wall is occupied by filiform rings, *i. e.*, it is annular.

This genus is in form allied to *Auliscus*, but if concatenate, approaches rather to *Gallionella*. In habit it is nearest to *Liparogyra*. It is remarkable by the marginal circle of apertures or pits.

Porocyclia *dendrophila*.—Elongate, cylindrical, the length double the width, smooth, with internal annual gyræ, nine in 1-324th; marginal pores twelve in number; the disc with very minute rows of dots, and with five central apiculi. Length 1-324th. Width 1-576th.

Genus Prorostaurus (Ehr.)—Has the characters of *Stauroptera*, except that its pair of terminal apertures are not marginal, but median (approximated in the median line.)

This may be considered a sub-genus of *Navicula;* it has been instituted by Ehrenberg, but we have not met with his account of the species.

Genus Pyxidicula (Ehr.) *The round-box Bacillaria.*—Lorica simple, bivalve, of a globose form, and marked by a furrow, along which it easily separates into two hemispheres. They are never concatenate or clustered. In organization this genus is closely allied to *Gallionella*, but differs in not forming chains like it. The contents of the lorica are of a greenish-yellow colour.

In 1836, Ehrenberg discovered, in the flints of the neighbourhood of Berlin, numerous spherical bodies, of pretty equal size, their diameter varying from 1-240th. to 1-1150th. These, he considered, probably belonged to the siliceous *Diatomeæ;* they occurred along with siliceous spicula of sponges, species of *Xanthidia* and of *Peridinium;* whether they should be placed in the genus *Pyxidicula* is doubtful, as no furrow or division was observed in their shell. (See Plate 12.)

Kützing, after having examined these bodies, has come to the conclusion that they cannot be reckoned with the *Pyxidicula*. This author admits *Pyxidicula* into the family *Melosireæ*, and thus characterizes it:—

"Individuals solitary, or conjoined in pairs, free, or sessile; primary side obsolete (absent), secondary side convex (lorica bivalve, valves convex, without interstitial rings.)"

In the absence of the ring (by which is meant the intermediate circular band), *Pyxidicula* differs from *Goniothecium*. (See that genus.)

Pyxidicula differs from *Coscinodiscus* by having its patellæ (valves) always contiguous, not conjoined by an intervening annular band. *Pyxidicula* also differs from *Discoplea*, in the recent state, by its convex non-involuted patellæ. In the fossil state this character vanishes, hence there will always arise a difficulty respecting fossil forms.

The genus *Pyxidicula*, has been sub-divided into several genera and sub-genera, by Ehrenberg; viz., the genera *Mastogonia*, *Stephanogonia*, and the sub-genera *Dictyopyxis*, *Stephanopyxis*, and *Xanthiopyxis;* moreover, the newly constituted genera *Goniothecium* and *Rhizoselenia* are closely allied to it.

P. *operculata*.—Transparent and spherical, containing yellowish-green granular matter (group 127, the upper figure is a group at right angles to that drawn on the left, shewing the furrow by which it separates; the figure to the right is a detached half; in the lower figure a transparent globular (glandular, Ehr.) body is observed.) No locomotion has been seen. Found abundantly in Autumn, in fresh-water ponds, along with *Naviculeæ*. Hampstead Ponds. Diameter 1-1440th. to 1-570th.

P. *globator*.—I insert under this name the globular bodies referred to above, found in flints. The section of pebble, containing the specimen from which Mr. Bauer's drawing in p. 12, figs 506 and 510 were made, was found on Brighton Beach. The figures are magnified 100 diameters.

P. *appendiculata*.—Subglobose; surface with cells in rows; a short eccentric cornu (appendix) proceeds from each segment (patella.) Diameter 1-624th. Richmond, Virginia.

P. *areolata*.—Surface of the centre of patellæ, punctate-areolate; areolæ heptagonal, with seven lateral, dotted areolæ. Diameter 1-960th. Petersburg, Virginia.

P. *apiculata*.—Oblong, sub-cylindrical, widely rounded on each side; surface of patellæ cellular, cells in longitudinal rows; each extremity hispid at the centre, with projecting points (apiculi). Diameter 1-888th. Virginia and Ægina.

P. *Coscinodiscus*.—Testules with a pair of discoid patellæ; surface

at the border extensively and minutely cellular; the centre of disc broad, but circumscribed and punctate. Has the habit of *Coscinodiscus disciger*. Diameter 1-648th. Virginia.

PYXIDICULA (?) *Actinocyclus*.—Testules with two flattened, finely cellular, and elegantly radiated patellæ, rays thirty-nine, straight and dense, reaching the centre. Diameter 1-720th. Richmond, Virginia.

P. *gemmifera*. Habit of *Coscinodiscus*. — Testules with turgid, crystalline patellæ, not bordered; with lax rows of crystalline nodules, fifteen of which nearly arrive at the centre. Diameter 1-864th. Maryland.

P. (?) *hirsuta*.—Subglobose, not cellular; with simple indistinct furcate hairs. Diameter 1-115th. Maryland. Habit of *Xanthidium*, but cleft into two patellæ.

P. *limbata*.—Oblong, with a central keel; patellæ in front with a central cellular surface, and thirty-two to forty radiating lines; border not cellular. Diameter 1-792nd. Maryland.

P. *prætexta*.—Patellæ two, not cellular, nor radiated, but with the border extending from the central area, overspread with rough points (hispid.) Diameter 1-1152nd. Ægina.

P. (?) *urceolus*.—Patellæ two, unequally urceolate; one elongated and more convex; the other shorter, extended on each side into a flattened margin; no cells, but smooth; ten rays in the long patella, and eight in the shorter, in the former smooth, in the latter apiculate. Diameter 1-1728th. Richmond, Virginia. See Xanthiopysis.

P. *cristata*.—Lenticular, patellæ two; no distinct rim, but a slightly prominent suture between the two contiguous patellæ; disc cellular; cells in rows. Diameter 1-816th. Richmond, Virginia.

P. *dentata*.—Convex, with a slightly dentated margin; teeth irregular, with very large cells, 6 in 1-1200th. Diameter 1-840th. Antarctic Ocean.

P. *longa*.—Oblong; its length two-and-a-half times greater than its breadth; cylindrical; apices rounded; suture longitudinal. Length 1-1080th. Fossil, Virginia.

P. *decussata*.—Found in the chalk marl of Ægina.

P. *hellenica*.—From the same locality. It = *coscinodiscus cruciatus* (Kütz.) and probably is *Dictyopyxis Hellenica* (Ehr.)

PYXIDICULA *major* (Kütz.)—Large, forming a bivalve, elliptic box; valves (patellæ, Ehr.) very convex, conical, regularly punctate. Diameter 1-420th. Virginia and Normandy.

P. *Adriatica.*—Adnate, sessile, of middle size, bivalve; valves convex, mostly hemispherical, and quite smooth. Diameter 1-600th. On Cladophora, Trieste. (P. 16, f. 33.)

P. *minor*, = P. *operculata* (Bailey).—Fossil. A doubtful species, and probably a detached frustule of a *Melosira,—Gallionella.*

P. (?) *compressa* (Bailey.)—Elliptical, bivalve; valves separated by a plane passing through the longer axis, slightly convex, and with transverse rows of dots. St. Augustine.

Sub-genus DICTYOPYXIS (Ehr.)—Those subglobose or turgid forms of the genus *Pyxidicula* which are characterised by a cellular constriction of the valves, are clearly and readily distinguished from those which have a single and continuous siliceous investment, or are furnished with appendages. I have therefore thought it right to separate the former cellular species from the others, and to constitute them a distinct sub-genus of *Pyxidicula*, under the appellation of *Dictyopyxis.*

"From the same genus—*Pyxidicula*—so abundant in forms, I have abstracted other distinguishable species, and have created the genera *Mastogonia*, and *Stephanogonia*, and the sub-genera *Stephanopyxis* and *Xanthiopyxis.*"

D. *cruciata* = *Pyxidicula cruciata* (1843). Resembles generally D. *Hellenica*, but differs in size, and has larger areolæ on its surface.

D. *Hellenica.*—Ovate, oblong; valves urceolate; surface with cells in longitudinal rows. Length 1-720th. Fossil in Greek marl.

D. *cylindrus* = *Pyxidicula cylindrus.*—Cylindrical, three times longer than broad; surface of valves (patellæ) with obscure rows of cells; apices rather tapering. Diameter 1-960th. Maryland.

D. *Lens* = *Pyxidicula Lens.*—Lenticular and flattened laterally; surface of valves cellular. Diameter 1-636th. Virginia.

D. *Scarabæus.*—Oblong, with unequal valves; when viewed laterally recalling the figure of the Scarabæus. Diameter 1-648th. Cells 14 in 1-1150th. Fossil, Virginia.

Sub-genus STEPHANOPYXIS.—Includes those turgid, bivalve, sub-

globose forms, which have a cellular testa, and in the middle of each valve a coronet of hooks (aculei) or a circular membrane.

STEPHANOPYXIS *aculeata* = *Pyxidicula aculeata* (1843.)—Subglobose, hispid. Diameter 1-1440th. Virginia.

S. *Diadema.*—Hemispherical, with parallel straight rows of cells; centre of disc depressed, with a circlet of closely set denticles. 13 to 14 cells in 1-1152nd. Dentations 30 in the full-grown circlets. Diameter 1-576th. Virginia.

Sub-genus XANTHIOPYXIS, comprising those forms with two turgid sub-globular valves, continuous, entire, and non-cellular, with a hispid, setose or winged (alate) figure.

Thus *Xanthiopyxides* are setose or alate *Pyxidiculæ,* with the habit of *Xanthidium*, or of *Chætotyphla*, but siliceous and bivalve.

X. *alata.*—Oblong, equally and widely curved on each side, and smooth, with the margin of the valves uneven or deeply dentate, expanded and setose. Diameter 1-552nd. Bermuda.

X. *globosa.*—Subglobose, hispid, with short setæ. Diameter 1-720th. Bermuda.

X. *oblonga.*—Oblong, equally and widely rounded at each end, surface beset with short setæ, occasionally connected by intermediate membranes, densely hispid. Length 1-552nd. Bermuda. Dr. Bailey, of New York, first pointed out and figured this species.

X. *constricta.*—Oblong; constricted at the middle, broadly rounded at each end, surface hispid with short setæ, occasionally conjoined by membrane. Length 1-384th. Bermuda.

X. *urceolus.*—Each valve urceolate, with the summit crowned by a round knob; apertures in the revolute margin. "I (Ehrenberg) have only met with single valves. In form they resemble *Stephanogonia*, but are not angular." Diameter 1-1560th. Fossil in Virginia.

Genus RHAPHONEIS (Ehr.)—Lorica, of two equal quadrangular valves, navicular, not concatenate; it is destitute as well of apertures and umbilicus, as of pinnules on its navicular sides, but possesses a median sutural line traversing them longitudinally.

It resembles *Surirella* in wanting the pinnules. The terminal aperture at the apices of the lorica appears to be single. It differs from *Cocconeis* and *Navicula* by the absence of the umbilicus.

RHAPHONEIS *amphiceros* = *Cocconeis amphiceros* (1840.)—Lanceolate, length three times the width, apices styliform; striæ transverse, granular, slender, 18 to 20 in 1-1200th. Length 1-576th. Cuxhaven, Virginia, Maryland.

R. *Fusus.*—Slender, linear lanceolate, four-and-a-half times longer than broad; apices styliform; striæ granular, slender, transverse, 17 to 18 in 1-1200th. Length 1-720th. Petersburg in Virginia. Approaches very near to *Fragilaria Amphiceros,* but differs by the median suture.

R. *Leptoceros* = *Cocconeis Leptoceros.* — Long, lanceolate, quadrangular or rhomboid; length three times the breadth; apices styliform, long, gradually tapering; striæ granular, transverse, slender, generally 18 in 1-1200th. Length 1-720th. Virginia.

R. *gemmifera.*—Large, elongate, lanceolate; length exceeding the breadth three-and-a-half times; apices long, gradually attenuate; striæ very strongly granular or pearly; 10 in 1-1200th. Length 1-300th. Maryland.

R. *pretiosa.*—Large, widely lanceolate, rhomboid; length twice the width, apices tapering gradually into a beak; striæ strongly granular, the granules looking like rows of pearls, 11 in 1-1200th. Length 1-480th. Maryland.

R. *Rhombus*=*Cocconeis Rhombus* (1840).—Small; widely lanceolate, rhomboid, sometimes sub-orbicular; length rather greater than the breadth; apices rostrate; striæ short, slender, granular, 20 to 21 in 1-1200th. Length 1-1152nd to 1-864th. Cuxhaven and Virginia.

R. *scalaris.*—Slender, lanceolate, acute at each end, with a double row of pinnules and intervening clear spaces (fenestræ) 9 in 1-1200th. Diameter 1-960th. Bermuda.

R. *fasciolata.* — Large, elliptic-lanceolate; length double the breadth; striæ fasciculate, minutely granular, strong, 7 to 8 in 1-1200th. Length 1-432nd. Antarctic Ocean.

R. *Scutellum.*—Slender, elliptic; one third longer than broad, with strong toothed (crenulate) striæ, 12 to 13 in 1-1200th. Length 1-864th. Antarctic Ocean.

Genus RHIZONOTIA (Ehr.)—Lorica bivalve, with two central apertures, with the character and form of *Amphora,* but by longitudinal

division often aggregated and connected in longitudinal series by the development of numerous siliceous off-shoots or radicles.

Rhizonotia resembles *Eunotia* or *Amphora*, or indeed *Cocconeis*, and is attached to Conferva, found in various rivers of Australia. The lorica has 5 longitudinal striæ, and appears rather rough or granular, but is very transparent; the contents are colourless, or very pale green.

RHIZONOTIA *Melo.*—Striated, rough or granular, but crystalline and diaphanous. By its mode of self-division, it becomes branched three to ten times. Within is a greenish granular matter. In Swan River, Australia.

Genus RHIZOSELENIA (Ehr.)—Its characters resemble those of *Pyxidicula* and of *Gallionella;* but the lorica is tubular, with one extremity rounded and closed, whilst the other is attenuate and multifid, as if terminating in little roots (radicles.)

These singular beings, as to their systematic arrangement, are yet doubtful; Ehrenberg having only met with imperfect fossil examples.

R. *Americana.*—Testules smooth, hyaline, tubular, interrupted by septa, one end round, the other styliform, and either simple or sending out branches like rootlets. Length of fragments 1-480th; breadth varies greatly. Fossil in Virginia and Maryland.

R. (?) *barbata.*—Testule short and small; breadth exceeding the depth; with the habit of *Dicladia;* central portion very narrow, transversely linear; apex presenting a short thick beak (rostrum) which is bearded (barbata). Length 1-1152nd. Virginia.

R. *Pileolus.*—Short and small; the width equalling the depth; with the habit of *Dicladia;* middle portion transversely linear; oblong, with a smooth median umbo posteriorly; with a short rostrum in front, and branched. Diameter 1-1320th.

R. *Campana.*—Testule large, with a conical extremity, much attenuated and terminating in rootlets; surface minutely granular. Length 1-264th. Bermuda.

R. *calyptra.*—Testules broad, conical, campanulate, smooth; apex attenuate, acute, recalling in figure the calyptra of the mosses. A fragment. Long diameter 1-480th. Southern Ocean.

R. *ornithoglossa.*—Testules tubular, conical, smooth and slender,

with a much attenuated acute apex, its figure, laterally, recalling that of the tongue of birds.

Genus SPHENELLA (Kütz).—Frustules on primary side cuneate, free, without stipes, and unattached; not enclosed by any common gelatinous investment.

Along with *Gomphonema* and *Sphenosira*, constitutes the family *Gomphonemeæ*, differing from the first in not being stalked, and from the second in its decided cuneate figure, and in not forming similar straight chains.

The several species are marine in habit and pretty generally distributed, none of them are identified by Kützing with any forms described by Ehrenberg.

S. *glacialis.*—Small on secondary side, lanceolate, with very fine transverse striæ. Length 1-1320th. Among Conferva. Monte Rosa.

S. *vulgaris.*—Small; very obtuse, on secondary side (*dorsum*, Ehr.), dilated at the middle, and finely striated. Length 1-1020th. In fresh water ponds among Algæ.

S. *obtusata.*—Small on secondary side, expanded above the centre, quite smooth; apices round and obtuse. Length 1-900th (P. 17, f. 31). Ponds. Nordhausen.

S. *angustata.*—Small, slender, narrowly cuneate and linear, conjoined in a flabelliform manner; on secondary side, quite smooth, very obtuse at the apex, rather dilated above the centre. Length 1-960th (Pl. 17, f. 30). Nordhausen.

S. *rostellata.*—Solitary, very smooth, broadly wedge-shaped; on secondary side, dilated centrally, acuminate at each end. Length 1-1020th to 1-720th.

Var. (*b*), *elongata.*—Larger; the apices produced and obtuse. Length 1-720th to 1-336th. Both found in fresh water. Nordhausen.

S. (?) *parvula.*—Small, very smooth on secondary side, lanceolate, acuminate at the apex, rather dilated at the produced base. Length 1-960th. Very like *Gomphonema.* Falaise.

S. (?) *Lenormandi.*—Small, navicular, very smooth; on primary side linear and truncate; on secondary, lanceolate and acute. Length 1-960th. Fresh water. Falaise.

This species presents navicular bodies intermixed with delicate fibres, and probably belongs to *Navicula.*

Genus Sphenosira (Ehr.)—Has the general characters of *Fragilaria*, but is made up of wedge-shaped bacilli, and so approaches *Gomphonema*. It occurs as a flattened band; the central umbilicus of the segments is distinct.

S. *Catena.*—Segments smooth, with the general form of *Gomphonema Auguris;* dorsally with one apex mucronate, the other gradually tapering and slightly obtuse. In fresh water. Mexico. (P. 14, f. 30).

Genus Staurosira (Ehr.)—The form of this genus is that of quadrangular *Fragilaria*: it is distinguished from the larger forms of the allied genus *Amphitetras*, by the absence of openings at the four angles.

S. *construens.*—Very small; smooth, spindle-shaped, angles produced, not quite equal. Length 1-6000th (P. 24, f. 5).

S. *amphilepta.*—Very small; smooth, produced at the angles; two opposite angles larger and more slender than the others.

S. *pinnata.*—Very small, but longer than the preceding two, produced at the angles, and on each side more so than the other.

S. *trigongyla.*—Characters unknown.

Genus Stephanodiscus (Ehr.)—Lorica of two equal orbicular valves, not in chains, without apertures or internal septa; valves equal, radiated, but with no constant number of rays; not cellular, but characterized by a marginal crown of denticles on each side.

Stephanodisci approximate in character to *Discopleæ*, but differ from them by the circlet of hooks. They recal the general form of *Gallionellæ*, but do not occur in chains.

S. *Berolinensis*; Small; nummiform (money-shaped), surface level, with acute marginal denticles (often thirty-two) on each side, with brown lobed ovaries (viz., the internal granular substance); disc minutely radiated. Diameter 1-1152nd. Alive at Berlin.

S. *Niagaræ.*—Larger, plane, nummiform, with acute marginal (often sixty-four) denticles on each side; the disc oftenwith sixty-four granular rays; granules at its centre not radiated. Diameter 1-432nd. Alive at Niagara.

Genus Stephanogonia.—This is one of the new genera formed by Ehrenberg out of his original genus *Pyxidicula*. Along with the characters of *Mastogonia*, its valves have truncate apices, and spinous angular umbilici.

STEPHANOGONIA *quadrangula.*—Testules thin, smooth, one valve with four angles, spines and rays, and a truncated apex; the other with six rays. Diameter 1-1152nd. Bermuda.

S. *polygona.*—One valve with sixteen (?) rays and spines; the other unknown. Bailey has figured this species.

Genus STEPHANOSIRA. (Ehr.)--Lorica utricular, truncate; each utricle capable of spontaneous fission through the centre, which being incomplete, developes chains; no apertures or internal septa in the disc; lateral aspect of disc (end view of segment), with very minutely dotted rays, not cellular, but with a marginal circlet (crown) of apiculi (and a central smaller crown).

In form this genus resembles *Stephanodiscus,* but differs from it, and becomes allied to *Gallionella,* by its imperfect spontaneous division and consequent concatenation. In *Gallionella,* however, the circlet of spines is wanting.

S. *Europœa.*—External surface of testules smooth, with their margin finely apiculated; chain formed of 3 to 4 segments, each segment (testule) 1-2304th to 1-1152nd in depth; rarely 1-1200th in width; often wider than long, like those of *Gallionella.* On Tree-mosses. Berlin.

S. *epidendron.*—Each testule cylindrical; the short surface, or that of its depth, with very minute dotted transverse lines; each valve with a median transverse suture, which, when self-division is proceeding, becomes a fissure; terminal disc with very minutely dotted striæ, and with both a central and marginal circlet of apiculi, the central of about four. Larger diameter 1-432nd; smaller 1-4320th. Guiana, South America.

S. *Hamadryas.*—Testules cylindrical; external or short surface smooth, but striated along the lines of junction, and hence the margin of detached joints appear denticulated; disc radiated around its margin, but the central area smooth, with some scattered dots, and its middle bearing the peculiar spikelets (apiculi). Diameter 1-720th. This and the preceding species have their segments filled with green granular matter (ovules, Ehrenberg).

Genus STYLOBIBLIUM. (Ehr.)—Lorica cylindrical, multivalve, not concatenated; valves in a simple straight series, like the contiguous leaves of a book, with a large median aperture opening into the

interior; entire (not perforated) at the ends; sculptured, and forming a cylindrical smooth tubule.

This genus approaches nearest *Biblarium*, which is allied to *Tessella*, but free; *Biblaria* are compressed and angular; *Stylobiblia* are rounded, and have a peculiar internal structure. The present genus has also an affinity with the obscure genus *Hemizoster* (which should perhaps be cancelled) by its cylindrical figure, but differs in having its surface sculptured.

Stylobiblium *Clypeus*.—Lateral valves orbicular, sculptured, with 15 to 20 radiant lines, three or four of which are often continuous at the middle; cylinders made up of 34 lamina (valves or leaflets). Diameter of valve 1-792nd. Fossil. Oregon and Siberia.

S. *divisum*.—Lateral valves orbicular; area of disc occupied with generally ten lines, interrupted by a clear large linear space at the centre. Diameter 1-600th. Fossil in Oregon.

S. *eccentricum*.—Lateral valves orbicular, loosely sculptured, with 5 to 7 eccentric curved lines, not broken (divided). Diameter 1-760th. A fragment of a cylinder contained nine leaflets. Fossil. Oregon.

Some forms of *Biblarium Rhombus* possess almost an orbicular figure.

Genus Symbolophora. (Ehr.)—Lorica of two equal valves, orbicular, not in chains, with incomplete cells and septa, the latter radiating a solid angular centre, surface not cellular.

Symbolophora differs from *Actinoptychus*, by all its cells being incomplete, by the centre being larger, more indistinct, and not circular, and by the surface of the valves being neither cellular nor granular, but occupied by very fine radiating lines.

S. *Trinitatis*.--With a remarkable crystalline triangular umbilicus, crenulate on its margin, angles rounded, the rest of the disc occupied by six bundles of very fine radiant lines diverging from the centre to the margin. Diameter 1-216th. (P. 14, f. 36.) Maryland.

S. *acutangula*.—Very close in habit and size to S. *Trinitatis*, but its central area (umbilicus) with acute angles. Fossil in Virginia.

S. (?) *microtrias*.—Turgid; disc with very finely dotted rays; umbilicus stellate, smooth; with three narrow rays. Diameter 1-480th. Antarctic Ocean.

SYMBOLOPHORA (?) *Tetras.*—Turgid; valves with very fine dotted rays; umbilicus stellate, smooth, crucial, or with four slender rays. Diameter 1-432nd. Southern Ocean.

S. (?) *Pentas.*—Turgid; disc with very fine dotted rays; umbilicus smooth, stellate, with five narrow rays. Diameter 1-432nd. Southern Ocean.

S. (?) *Hexas.*—Testule turgid; disc like that of the preceding, but the stellate umbilicus with six slender rays. Diameter 1-432nd. Southern Ocean.

Genus SYNDENDRIUM. (Ehr.)—Lorica bivalve, not concatenate; subquadrangular, with no central umbilicus; one-celled; valves unequal, rather turgid; one smooth, the other with numerous styles or corniculi branched at the apex, and distributed upon the flat centre of the valve, the margin being bare. This differs from the nearly-allied genus *Dicladia*, by the valve having not merely two but many styles.

S. *Diadema.*—Testules lanceolate; 5 to 6 spines in the centre of one valve, forked or pencillate (split up in a brush-like manner) their length equalling the thickness of the testa. Diameter 1-1152nd. In Peruvian Guano.

Genus SYSTEPHANIA. (Ehr.)—Lorica orbicular, bivalve, concatenate? Testa of valves cellular (*areolate*) not radiated, nor divided by septa; with an external circlet of spines, or an erect membrane, on the central portion (disc) of each valve; not on the margin. Has the habit of a *Coscinodiscus* (as of C. *lineatus*), but the circlet of spines unites the adjoining corpuscles during spontaneous fission, and in the young state. Thus *Systephania* differs from *Coscinodiscus*, as *Denticella* differs from *Biddulphia*.

S. *aculeata.*—Valves loosely cellular; cells disposed in parallel rows, 8 in 1-1152nd; aculei not dense, 12 placed on the disc, but near the margin. Diameter 1-324th. Bermuda.

S. *Corona.*—Valves more densely cellular, and in parallel rows, 12 in 1-1152nd; with 48 erect aculei, closely set and near the margin. Diameter 1-348th. Bermuda.

S. *Diadema.*—Valves densely cellular; cells in parallel rows, 14 in 1-1152nd, aculei bent inwards, marginal, conjoined at their extre-

mities by a membrane, about 28 in the entire circle. Diameter 1-864th. Bermuda.

Genus TABELLARIA.—Kützing defines it thus:—"Bacilli adnate, obsoletely stiped, at length partially separating, concatenate; longitudinally and interruptedly vittate; inflated at the apices, and on the secondary side." He adds, "it is distinguished from both *Fragilaria* and *Striatella* by having a large central aperture." The family *Tabellarieæ* contains *Tetracyclus, Tabellaria Terpsinöe,* and *Grammatophora. Tabellarieæ* are essentially of fresh-water habit, and are very widely distributed. They occur both living and fossil.

In his article on *Diatoma* (Ann. Nat. Hist., vol. x., 1843, p. 449) Mr. Ralfs, speaking of that genus, and including also *Tabellaria*, alludes to their unattached filaments as a characteristic; but, according to Kützing, both these genera are obsoletely stalked. If the latter be correct, both the present genus and *Diatoma* should have found their place among the ECHINELLEA.

Mr. Ralfs further remarks—"The British species of this genus form two very distinct groups . . . . . I believe distinct genera, called by Mr. Shuttleworth, *Diatoma* and *Tabellaria*. 1. *Diatoma.*—In this no striæ are seen on the front surface, and there is no transverse canal (vitta of Kützing); whilst the lateral surfaces have transverse striæ, the ends of which appear along the margins of the frustules, when these are in their usual position. 2. *Tabellaria.*—In this group two or more longitudinal striæ, interrupted in the centre by a canal, are seen on the front surface, but there are no striæ on the lateral surfaces."

Tabellaria appears to be distinguished from Ehrenberg's genus *Tessella*, by the transverse canal interrupting the striæ.

T. *Lævis=Diadesmis lævis* (Kütz.)—Very small, smooth, length five times the breadth (P. 15, f. 40).

T. *biceps.*—Very small, smooth; very turgid at the centre, laterally, ends more slender and capitate. Fossil in Ireland and in North America.

T. *Gastrum.*—Very small, smooth, laterally with a sub-globose median swelling, ends capitate, rather narrowed. Labrador.

T. *nodosa.*—Small; with five fine nodosities (nodes), of which the

central is somewhat the largest; approaches *Grammatophora undulata*. Fossil in Ireland.

TABELLARIA *sculpta* = *Diadesmis sculpta* (Kütz.)—Resembles *Pinnularia Borealis*, but is sometimes to be met with combined in fours.

T. *robusta*.—Testule thick; length three times greater than the breadth; widely capitate on each side; centre widely gibbose, with subacute capituli. Length 1-864th. Fossil in Connecticut.

T. *trinodis* = *Navicula* (?) *trinodis*.—Linear, elongate, presenting three undulations, the middle of which is the chief; on the sides, inflated. Fossil in Sweden and Ireland. Length 1-860th to 1-480th.

T. (?) *amphicephala*.—Very small, much dilated at the middle; apices capitate. Length 1-1728th. Has the habit of *Biblarium Follis*, but with thickened apices. Mountain meal of San Fiore.

T. *Bacillum* (Ehr.)

T. *clavata*. (Ehr.)

T. *undulata* (Ehr.)

The genus *Tabellaria* of Kützing contains the following species not occurring in Ehrenberg's enumeration, being either actually new or otherwise differently placed and named.

T. *flocculosa* = *Bacillaria Tabellaria*, and *Navicula* and *Tabellaria trinodis* (Ehr.) (P. 16, f. 29.)

T. *ventricosa*.—Joints tabulate, vittæ alternate on the sides (end view), much inflated in ventricose manner. Length 1-960th. In Fresh water. Falaise. (P. 16, f. 26.)

T. *fenestrata*.—Joints oblong, vittæ opposite; laterally, inflated equally at the middle and at the two ends. Length 1-600th to 1-280th. In ponds and streams. England, France, &c. This species not improbably = *Tabellaria nodosa* (Ehr.) Frustules four times or more longer than broad.

T. *marinum* (Lyngb. and Ralfs.) = *Tessella interrupta* (Ehr.)—Frustules varying from nearly square to six times as long as broad; canal not inflated; striæ two. Dark brown when recent, greenish when dry. Common or marine Algæ.

"The mucous substance which forms the connecting medium between the angles of the frustules is more developed in this than in the other species."

TABELLARIA *minimum* (Ralfs.)—Frustules very minute, about twice as long as broad; nearly colourless. No striæ visible. Found on Conferva, Penzance.

Genus TERPSINÖE. (Ehr.)—Lorica bivalve, compressed, quadrangular, free; breadth exceeding the length; made up of three cells, each cell intersected by two septa, recalling the appearance of bars of music, each bar presenting also curved bodies resembling notes.

These large and well marked forms approach nearest to the African genus *Tetragramma,* which has four septa, and musical, note-like cells, and is nearly as long as broad. Each of these genera exceeds in size the similarly formed cells of *Grammatophora.*

Kützing's description rather differs:—

"Bacilli tabulate, attached, obsoletely stiped, at length parting, and concatenate by an isthmus; with transverse (not pervious) and capitate vittæ, shortened and marginal; on secondary side nodose. On the upper surface, or face of the quadrangular plates, is a vaulted elevation, extending outwards on each side to the margin; and which is well seen when the lorica lies on one of its narrow sides."

T. *musica.*—Lorica two to three times broader than long; very finely punctated longitudinally, having two transverse smooth bands, more or less apart. (P. 14, f. 47.) In salt and fresh water. Vera Cruz, Mexico.

Genus TESSELLA. *The flat chain Animalcules.*—Filaments free, for though often entangled together, they are never attached; lorica bivalved or multivalved, prismatic, and expanded so as to have a tabular compressed form. In consequence of perfect self-division of the lorica, and imperfect division of the body, they are developed in the form of gaping chains or zig-zag clusters. In organization they stand between *Achnanthes* and *Bacillaria.* No opening in the lorica has been distinctly seen; longitudinal clefts are present, and essentially characterize this genus. The ova cluster has numerous lappets, and looks like a great number of round yellowish-green coloured spots, which are not the ova themselves, but the structure containing them.

The genus *Tessella* of Kützing, a member of the family *Striatelleæ,* contains but one species, viz., T. *interrupta,* the two other forms described by Ehrenberg being placed in other genera, viz., T. *arcuata* in *Striatella,* and T. *Catena* in *Rhabdomena.* The characters are thus

given—"Bacilli broadly tabular, not concatenate, densely and longitudinally vittate; the vittæ interrupted at the middle, and alternating: stipes none."

In assigning it as a character that *Tessella* does not form chains or occur as filaments, Kützing differs materially both from Ehrenberg and Ralfs, both of whom state the contrary as the case.

Tessella differs from *Striatella*, as its filaments are not attached; from *Tetracyclus*, as its frustules here and there cohere at their angles; and from *Tabellaria*, as its striæ are not interrupted at the centre. (Ann. N. H. 1843, p. 104).

Kützing asserts that Mr. Ralfs has erred in identifying the species described by him as *Tessella Catena* with that possessing the like name in Ehrenberg's work.

Mr. Ralfs writes, "*Striatella, Tabellaria, Tetracyclus*, and *Tessella*, form a distinct group of the *Cymbelleæ (Diatomæ)*, distinguished from the other genera by having striæ on the central portion of the frustule." Again, speaking especially of *T. Catena*, "From my specimens I was unable to ascertain whether the filaments were *attached or not*, they are fragile, and here and there cohere at their angles in the same manner as *Striatella arcuata* . . . . but, unlike the last, are less fragile, and turn green in drying."

TESSELLA *Catena*.—Lorica tabular, often broader than long; with from 4 to 24 longitudinal series of transverse striæ, and a double row of marginal vittæ (see f. 180, 181, and 182), lateral surfaces striated, contracted near the ends. Found on sea weeds. Length of table (that is breadth of the bands) 1-570th to 1-240th.

T. *arcuata* = *Striatella unipunctata (*Kütz.*)*—Is nearly square and marked with continuous longitudinal lines, but not with transverse striæ. Kützing describes it as having stipes. Length 1-430th.

T. *interrupta*.—Is nearly square, with the longitudinal lines interrupted in the middle; striæ none. Length of table 1-570th. On the English coast, &c.

Genus TETRACYCLUS. (Ralfs).—Filaments free, attenuated, and forming the segment of a distinct circle; frustules longitudinally striated (Ann. N. H. v. 12, p. 105).

T. *lacustris*.—Frustules (testules, Ehr.), about twice as broad as

long; lateral surfaces with from 7 to 9 distinct transverse striæ. Found at Dolgelly, in Wales (P. 14, f. 24 and 25).

"I was at first inclined to refer this plant to Ehrenberg's genus *Tessella*, but more minute examination convinced me that it could not be placed there. The frustules are striated as in *Striatella* and *Tessella*, but it differs from the former genus in not being attached, and from both, as the frustules do not cohere at the angles, forming a chain. In the curious forms of the filament it differs equally from these genera and all the other Diatomaceæ, except perhaps *Tabellaria*, in which the inflated canal produces a distinct resemblance. The endochrome is of a dark green colour, and is often collected into an irregular spot."

Genus TETRAGRAMMA (Ehr.)—Lorica, bivalve, compressed, quadrate, free, unilocular, broader than long, with two pairs of septa within each cell interrupted (incomplete) in the middle, and there expanded so as to produce the appearance of four musical notes. This genus is allied to the peculiar Mexican genus *Terpsinöe*. Species unknown.

Genus TRICERATIUM (Ehr.)—Individuals free, with a bivalve, triangular lorica; on each side tridentate or corniculate; not concatenate; multiplied by longitudinal self-division.

T. *favus*.—Triquetral, plane or slightly convex on the sides, angles obtuse, surface with hexangular cells, of large size and yellow in colour, dorsum with a smooth central zone. Diameter 1-200th. Alive at Cuxhaven, Vera Cruz, the Thames, &c., and fossil in chalk marl of Greece and elsewhere. (P. 14, f. 43, 44.)

T. *striolatum*.—Triquetral, with convex sides, and subacute angles; surface with very finely dotted lines; dorsum with a smooth central zone. Alive. Diameter 1-290th.

T. *obtusum*.—Large, triangular, with convex sides; angles widely rounded, but less so than in T. *amblyoceros*; surface minutely dotted, granules ten in 1-1200th.

T. (?) *amblyoceros*.—Large, triangular, with convex sides, and widely rounded angles, with very fine radiating rows of granules, of which there are twenty-four in 1-1200th. Diameter 1-456th. Virginia.

TRICERATIUM *Reticulum.*—Smaller, granules small, not radiating, straight. Approaches T. *Pileus.*

T. *acutum.*—Sides straight, apices acuminate, cells not radiant, ten in 1-1150th. Diameter 1-720th. Bermuda.

T. *condecorum.* — Sides slightly convex, apices obtuse, surface ornamented with rows of fine granules in elegant curves, and radiant; granules fifteen in 1-1200th. Diameter 1-384th. Bermuda.

T. *Solennoceros.* — Sides deeply concave, apices long, tubular, radiant, subacute, surface covered with granules, radiating in straight lines; granules fifteen in 1-1200th. Diameter 1-276th. Bermuda.

T. *undulatum.*—Sides rather convex and undulated; undulations three or four on each side; surface adorned with minute granules, disposed in elegantly curved radiating lines. Diameter 1-480th. Bermuda.

T. *Pileolus.*—Very small, triangular, sides concave; angles much produced but obtuse; surface with small scattered cells. Has the form of T. *Pileus*, but the sculpturing and dimensions of T. *Reticulum.* Diameter 1-576th. Southern Ocean.

T. *megastomum.*—Triangular, sides straight; central area hexangular, minutely but irregularly punctate; apertures very large, entirely occupying each of the angles. Diameter 1-1200th. Fossil in African and Peruvian Guano.

T. *Pileus.*—Triangular, sides concave, angles produced, rather acute, cells in radiating series; smaller than those of T. *favus.* Diameter 1-288th. Fossil in Greek marl.

T. *comtum.* (?)—Habit and general characters of T. *favus*, but has each of its cells armed with a forked (furcate) spine.

T. *alternans* (Bailey.) — Small, reticulated, triangular; surface marked with three lines, which, with the portions cut off from the sides, form a hexagonal figure. Common everywhere along the Atlantic Coast, and in estuaries; also abundant, in the fossil state, in the infusorial strata of Virginia, and in the rice-fields of Georgia and Carolina.

Genus ZYGOCEROS (Ehr.)—Free (?) compressed, navicula-shaped, bivalve, siliceous; each end provided with two perforated horns; self-division complete, hence frustules not concatenate.

ZYGOCEROS *Rhombus.*—Large; testule laterally turgid and rhomboid, angles rounded, surface with very fine granular striæ; dorsally with a smooth central zone. Striæ twenty-four to twenty-six in 1-1150th. Diameter 1-290th.

Z. *Surirella.*—Small, compressed laterally, lanceolate, with constricted and obtuse apices; surface with granular lines converging to the centre; dorsally, with a wide smooth zone. Diameter 1-720th. Alive. (P. 14, f. 50, 51.)

Z. (*Denticella*?) *mobiliensis* (Bailey.)—"Frustules quadrangular, compressed, thin, delicately decussatedly-punctate; lateral processes slender; intermediate ones (two at each end) long and slender. Colour yellowish. I first detected this species in 1848, in soundings from Mobile Bay, and subsequently at Savannah."

Z. (?) *Bipons.*—Lanceolate laterally, each end acute; and prolonged as a small horn, two shallow constrictions at the middle surface delicately granular, not radiated. Diameter 1-384th.Bermuda.

Z. (?) *stiliger.*—Surface loosely cellular, lorica produced into two long acute styliform horns; a double stricture about the middle, laterally. Diameter 1-1152nd. Bermuda.

Of the two last species (says Ehrenberg) I have seen but fragments, and their true nature is therefore uncertain. Z. *Stiliger* may be a species of *Hemiaulus;* but the constrictions in both resemble the *Biddulphia,* save that they are wanting of the wide apertures of the horns.

Z. (?) *Australis.*—Smooth, navicular, and turgid laterally; horns on the sides obsolete, apertures conspicuous. Diameter 1-480th.

Z. *Navicula.*—A species discovered in marl from Ægina.

Sub-section II. ECHINELLEÆ.—Lorica simple, attached, with or without a distinct stalk,(stipes.)

Genus ACHNANTHES (Ehr.) *The Standard Shaped Animalcules.*—Lorica simple, composed of two or more pieces; form prismatic, longer than broad, with a central pore (umbilicus.) The individuals, solitary or aggregate, are attached by a lateral pedicle (stipes) proceeding from one end of their ventral surface. They are developed in the form of simple pedicled chains (tablets or bands) resembling standards; self-division longitudinal with reference to individuals, but trans-

verse with respect to the bands; when incomplete, we have concatenate, when complete, single forms; it is seen to commence beneath the transparent siliceous lorica. The members of this genus are found, both in salt and fresh water, parasitic on Algæ, in all parts of the world; several species have also been met with fossil.

This genus, *Achnanthes*, is a member of, and gives the designation to the family *Achnantheæ* of Kützing; which also comprises the genera *Achnanthidium* and *Cymbosira*. As a family it most nearly resembles *Striatelleæ*, but the latter want the umbilicus of the *Achnantheæ*.

We add the following particulars from Mr. Ralfs:—

"The upper margin of the frustules of *Achnanthes* is convex; the lower one concave. In some species the lateral portions are turgid, the central portion looking like a band between them; in others they are flat, and do not enter into the front view. The superior lateral surface differs from the lower one in the absence of the central transverse pellucid line, which is present in the lower, and by its terminaton forms the punctum seen in the front view. The mode of growth in this genus resembles that in *Isthmia*, except that the frustules finally separate without cohering at their angles."

"*Achnanthes* differs from all other *Diatomacea*, except *Striatella*, by its stipitate, flag-like fronds; and from *Striatella* it may be known by the absence of internal siliceous plates; and even a solitary frustule of this genus may be distinguished from that of any other, by its curved form, and by the punctum in the middle of the lower margin." (Ann. Nat. Hist. v. 13, p. 490.)

Achnanthes *longipes*.—Large, striated, curved (excised), at the middle on the ventral aspect; convex dorsally; ends obtuse, rounded; end view, elliptic-oblong; pedicle thick, from two to five times the length of the lorica; supporting but few individuals. Transverse striæ ten in 1-1200th. Length (*i. e.* breadth of band) 1-570th. to 1-120th. The central portion of each frustule appears like a band between the turgid lateral portions. Common in sea-water.

A. *brevipes*.—Resembles the preceding generally; differing, however, in the end view, which is suddenly and shortly acuminate,

and particularly in its pedicle being of less length than the individuals it supports (figs. 199, 200, 201.) The clusters are sometimes many inches in length, (fig. 202 a more magnified specimen.) Length 1-860th. to 1-180th. In salt water.

ACHNANTHES *subsessilis.*—Rather small, slender, striated, slightly bent, rectangular; individuals single or binate; end view oblong or elliptic, with rounded apices; stipes thick, very short, or almost wanting (obsolete.) Length 1-1150th. to 1-430th. Var. *b. multiarticulata;* in which more than two individuals are conjoined in a band. Common in fresh and salt water.

A. *Exilis.*—Small, slender, quite smooth, rectangular; end view lanceolate, acuminate; pedicle slender, often longer than the body. Length 1-1150th. to 1-570th. On Confervæ in fresh water; not common. Dark reddish brown when recent.

"The *Achnanthes exilis* (Ralfs) agrees with Kützing's specimen in its crowded habit and elongated stipes, but its frustules are much smaller, and its lateral surfaces less acute, in both which respects it is intermediate between A. *minutissima* and A. *exilis,* (Kütz.)"

A. *minutissima.*—Very small, slender, and smooth; end view lanceolate; stipes fine, short, or about the length of an individual. Length 1-1200th. to 1-800th. Common on fresh water Algæ and Confervæ. This and A. *exilis* differ from the other species by their fresh-water habit; from A. *exilis* it differs by its short stipes, and its less acute lateral surfaces.

A. *inequalis.*—Unequally bent, and smooth. Fossil in Sweden.

A. *pachypus.*—Small, finely striated, slightly curved at the centre of ventral surface; dorsum rather turgid, apices rounded, angles obtuse; end view lanceolate-elliptic; pedicles very short and thick. Length 1-1730th. to 1-1320th. Brackish water, Peru. Young specimens of A. *subsessilis* are very similar to the present species, which has seldom more than three joints, never more than four; Dr. Montagne, its first describer, gives only two.

A. *rhomboides.*—Frustules very turgid, ventral surface with acute extremities, and rhomboid-lanceolate; stalk distinct, short and thick.

A. *turgens.* — Viewed laterally (in front view, Ralfs) the lorica is three times longer than broad; ventrally, oblong-lanceolate,

obtuse. This species is more dilated than A. *pachypus*, but in other respects similar; stalk obsolete, Length of frustule 1-480th.

ACHNANTHES (?) *paradoxa.*—Ovate, obtuse; length double its breadth, marked by transverse scabrous, dotted lines. Lines sixteen in 1-1152nd. Length 1-900th. No apertures observed. If a *Fragilaria?* Found fossil at Norwich in Connecticut.

A. *bacillaris.*—In striated narrow wands (bacilli), each slightly curved inwards at the centre, both dorsally and ventrally, equally bacillar; apices simply rounded; the wands often in very long chains, with short foot stalks (pedicles.) . . . . It is smaller than A. *longipes*, and slenderer than A. *brevipes*, and is made up of twenty segments.

A. *capensis* (Kütz.)—Striated, rather small, turgid, angles obtuse, but few conjoined; secondary side (ventral surface, Ehr.) lanceolate, elliptic-oblong; stalk elongated, very thick.

Var. *(b.)* many frustules conjoined. Length 1-600th. On Conferva, from Table Bay.

A. *Carmichaeli* (Grev. and Kütz.)—Very large, striated, angles obtuse, few conjoined; very turgid, with ventral notch; dorsum convex, rather recurved at the extremity; twelve transverse striæ in 1-1200th; stalk very thick and long. Length of frustule 1-180th. On the smaller filiform marine Algæ.

A. *genuflexa* (Kütz.)—Striated, small; angles obtuse, turgid, very much bent (genuflexed); stalk short, not very stout. On marine Algæ, Genoa.

A. *intermedia* (Kütz.)—Striated, size intermediate, angles obtuse, but few conjoined; turgid, secondary side sublinear, apices cuneate, acute, stalk shortened, delicate, but distinct. Parasitic, Berlin.

A. *multiarticulata.*—Striated, angles not very obtuse, many conjoined, turgid; secondary side elliptic-lanceolate; stalk short and thick. Length 1-312th. Gulf of Venice and Trieste.

A. *parvula.*—Quite smooth, minute, primary side with wider and more obtuse angles, scarcely curved; secondary, elliptic-oblong, obtuse; stipes rather thick and extended. On Ulva, in brackish water.

A. *Arenicola* (Bailey.)—Frustules minute, rectangular, or slightly

curved; end view lanceolate, striate; small plates, composed of two or three frustules, supported by a short pedicle. Were found abundantly on grains of the beach sand, below high water mark, at Fort Brooke, Truspa It is possibly a species of *Hyaloseira*, but requires further study.

Genus Achnanthidium, (Kütz.)—Individuals solitary, or binate, free (not adnate); primary side (dorsum) linear, bent (genuflexed.)

A. *Microcephalum.*—Secondary side lanceolate; each end capitate. Length 1-1680th. Marine. Common among other Diatomacea. (P. 17, f. 15.)

A. *delicatulum.*—Secondary side ventricose; extremities prolonged. Length 1-1680th. In brackish water. (P. 17, f. 16.)

Genus Amphitetras, (Ehr.) — Lorica simple, bivalve or multivalved; quadrate, with four openings on each surface, viz. one at each angle; self-division imperfect; but the chain-like masses which the individuals form, are not gaping, as in some other genera.

This description differs from that by Mr. Ralfs and Kützing, chiefly in respect of the non-attachment of the members. Ralfs thus characterizes the genus:—

"Filaments attached by one of the angles of the basal frustule; frustules cubiform, rectangular, or, more frequently, with all the angles slightly produced, reticulated, cohering in a zig-zag chain." Along with *Biddulphia* and *Denticella*, *Amphitetras* approaches very near to *Fragilaria:* it is far removed from *Staurastrum*, to which it bears considerable external resemblance, (Ehr.)

Mr. Ralfs observes: "This genus agrees with *Isthmia* and *Biddulphia*, in the reticulated structure of the frustules; in the great size of the lateral surfaces, between which the central portion appears like a band; in the produced angles, which are situated entirely in the lateral portions, and in cohering at the angles, and thus forming a zig-zag chain. It also agrees with these genera in their peculiar mode of growth; but it differs from *Isthmia*, in having all its angles equal, and from both in having a four-sided, and not a compressed figure."—(Ann. Nat. Hist. v. 12, p. 275,)

Amphitetras is one member of the family *Anguliferæ*, of Kützing, which includes besides, *Lithodesmium* and *Amphipentras*, and is

characterized by the angular figure of its genera; which, too, are all marine.

AMPHITETRAS *antediluriana.*—Minute, cubical, cellulose, (reticulated); lateral surfaces radiated; angles either obtuse, or prolonged, and hence the sides also straight, or curved. Living on the sea coast of Denmark, England, Jamaica, &c.; fossil in the chalk marl of Oran and Greece. Diameter 1-850th to 1-430th. (P. 14, f. 21, 22.)

Individual loricæ (frustules) unite, sometimes as many as thirty together, in a filamentary form; and in a recent state exhibit a brown colour. "On a lateral view the figure is quadrangular, with concave sides, and at each angle there is either a round opening, or a large and more strongly marked cell, which presents the appearance of one. The central portion is four-sided, and its reticulations, which are smaller, are frequently arranged in lines. Mrs. Griffith aptly compares the figures of the separated frustules to bales of cloth made up with bands for exportation." (Ralfs.)

A. *parallela.* — Testules quadrate, with straight sides, and obtuse angles; the cells on the side disposed in parellel straight lines; apertures of the angles obscure. Diameter 1-144th. Found in Greek marl.

Genus BIDDULPHIA, (Gray,)—Filaments attached, frustules siliceous, quadrilateral, minutely reticulated, cohering by their alternate angles, and thus forming a zig-zag chain; the angles are equal and elongated into tooth-like projections, (horns, Ehr.)

Biddulphia, like *Isthmia,* has reticulated turgid frustules, which cohere by the elongatad angles. It has also the lateral portions so inflated, that they seem a part of the front of the frustule, the central portion appearing like a band between them. The mode of growth in this genus is also similar, but it differs in having all the angles elongated and equal. At first the frustules are connected to each other by the adjoining angles.

The generic characters are borrowed from Mr. Ralfs, (Ann. Nat. Hist. vol. xii. 1843,) not having met with the paper of Ehrenberg detailing them.

This genus gives name to the family *Biddulphia,* of Kützing, in which it is associated with *Isthmia, Odontella,* (Kütz.) and *Zygoceros.*

Biddulphia *pulchella* (Ehr.)—Quadrangular, compressed, with from three to five small obtuse lateral processes. In the sea, near Cuba; and fossil in the chalk marl of Greece. Diameter 1-290th. It is also found on the English coast; and Mr. Ralfs has described it thus:—"Frustules distinctly reticulated; surfaces lateral, with one or three rounded projections between the angles, and marked with a few distant striæ, which appear to arise from the depressions between the projections. (P. 13, f. 46, 47, 49, and 50.)

"It is brownish when recent, and becomes paler in drying. Filaments elongated, attached; angles of frustules rounded, and occasionally constricted at their base. There is *no* constriction at the junction of the lateral portions with the central one, as occurs in B. *aurita*." Ehrenberg enumerates three to five lateral processes; Ralfs one to three; but this apparent discrepancy is removed by the circumstance, that the latter observer does not count the angles of the frustules as lateral processes, which Ehrenberg does.

B. *aurita* (Ralfs) = *Odontella aurita* (Kütz.)—Frustules (testules, E.) very minute, quadrilateral, cellulose, structure indistinct, lateral portions without striæ, constricted at their junction with the central one, and destitute of striæ.

"This species differs from B. *pulchella*, in the same manner as *Isthmia enervis* does from *I. obliquata*, viz., in the absence of striæ. But it also differs from B. *pulchella*, by its smaller size, obscure reticulations, and by its constrictions."

B. (?) *lunata.*—Smooth, with three lobes on the side, slightly curved, lunate, and with subacute horns Diameter 1-864th.

B. (?) *Gigas.*—Large, very turgid at the centre; rough, without distinct granules, laterally presenting five segments, having a large oblong aperture in the tapering apex of each side, which, therefore, is tubular. (?) Diameter 1-144th. Bermuda.

B. (?) *ursina.*—Large, turgid, not cellular; sides furnished with hairs; without constrictions; central area smooth. Diameter 1-192nd. Does it belong to *Hemiaulus.* (?) Its hairiness is remarkable, and approaches it to *Tetrachæta.* It is described by Dr. Bailey.

BIDDULPHIA *cirrhus.*—A new species, in earth from Barbadoes.

B. *Tridens* = *Denticella Tridens* (1838.)—Kützing is disposed to consider this identical with his *Biddulphia trilocularis.*

B. *lævis* = (Bailey), *Odontella polymorpha* (Kütz.) — Lorica smooth; margin entire; each angle produced and conical, but obtuse; very small.

B. *Trioloculаris* (Kütz.)—With two septa on the sides, and three cells. Cuba, Peru. Kützing considers B. *pulchella,* and *Denticella Biddulphia* (Ehr.) to be forms of this species, and probably also *Denticella tridens.*

B. *Qinquelocularius* (Kütz.)—With four lateral septa, and five cells. Not uncommon. This, too, partly corresponds to the B. *pulchella* (Ehr.)

B. *Septemlocularis.* — With six lateral septa, and seven cells (loculi.) Canary Islands.

Genus CLIMACOSPHENIA.—Lorica simple, longer than broad, sessile or free, wedge-shaped, divided into cells by internal septa, disposed like the steps of a ladder (scalariform.)

This genus resembles *Podosphenia* or *Echinella,* except in having the peculiar transverse septa.

C. *moniligera.* — Minutely striated transversely on the sides (margins); septa ten to eleven in number. (P. 14, f. 45, 46.) Cuba, Mexico.

C. *australis.*—Very shortly stalked; margins smooth. On Algæ, New Holland.

Genus COCCONEMA.—Lorica simple, siliceous, composed of two or more pieces; longer than it is broad; attached by one of its extremities to a pedicle, in the direction of its axis; it is smooth externally, and transversely furrowed internally; it has two central and four terminal (*i. e.* two at each extremity) openings; hence this genus is closely allied to *Navicula,* and its members might be called *pedicled Naviculæ,* were it not that their two sides are not symmetrical; although, indeed, in this respect, a transition is exhibited by *Navicula inequalis.*

The granular contents are of a brownish or greenish colour, and divided into four parts; one or two bright shining spots (vesicles)

represent the seminal gland of Ehrenberg. Self-division longitudinal and ventral, the parts dividing themselves before the restoration of the original form, which, indeed, in some specimens, is never restored, the portions remaining like bows, or semi-lunar-shaped pieces. After division both the halves gape, and take an apparently oblique position in regard to the stalk; those bodies which are separated from their stalks have a free movement.

Kützing thus characterizes the genus *Cocconema,* as one of the family *Cymbelleæ,*—"Individuals solitary or geminate (in pairs), stalked; in other respects like *Cymbella.*"

From *Epithemia* it differs in having a central umbilicus; from *Amphora* and *Navicula,* by its asymmetrical form; and from all three, also, by being stalked. From the allied stipitate genus *Gomphonema,* the central umbilicus constitutes the mark of distinction.

The individuals are probably solitary and free in the earliest stage, the stipes being a subsequent development.

Besides propagating by fission, the members of this genus are known to exhibit the process of conjugation. The latter has been watched by Mr. Thwaites in *C. lanceolatum,* and, unlike what mostly occurs, the developed, sporangial bodies, have a close resemblance to the original frustules, the chief difference being in their larger size.

Most species of *Cocconema* are of fresh-water habit; several have been found fossil.

COCCONEMA *Boeckii.* — Large, lanceolate, subacute at the extremities, striated, and attached to a branched pedicle. Ehrenberg states he has not seen a central opening, but that there is one near each end on the ventral aspect. Found in sea-water, North Sea and Baltic. Striæ twenty-six in 1-1200th. Length 1-430th. to 1-210th.

C. *lanceolatum.*—Semi-lanceolate, closely striated; ends obtuse, attached to a dichotomously branched pedicle, in which it differs from *Eunotia turgida,* as also in the presence of a central opening in the lorica. (P. 4, f. 194, 195.) Length 1-210th. to 1-120th.

C. *cistula.* — Small, semi-ovate, obtuse, striated; pedicle long, simple, and sometimes branched; central openings distinct, terminal ones obscure. Free specimens resemble *Eunotia faba;* the young are

semi-lunate; (figs. 196, 197, 198.) Found living on aquatic plants, and fossil at Cassel, San Fiore, and Jastraba, in Hungary. Length 1-430th. to 1-1150th.

Cocconema *cymbiforme.*—Slender, lanceolate; extremities subacute; on the other side, linear-oblong, truncate-obtuse; transverse striæ sixteen in 1-1200th. Stipes filiform, obsolete, (imperceptible individually) in the intricate, jelly-like mass they form. Common length 1-500th to 1-150th. (P. 15, f. 46.)

C. *gibbum.*—Semi-oval; transverse striæ rather fine; slightly constricted at the ends which are produced and punctate; stipes branching dichotomously; rather stout. Length 1-480th. Alive and fossil (P. 16, f. 10.)

C. *asperum.*—Habit and dimensions of C. *lanceolatum*, but with the striæ denticulate, or interrupted by dots (puncta.) Length 1-288th. Fossil in France.

C. *Græcum.*—Habit of C. *Cistula*, with stronger, but fewer striæ; only twelve to thirteen in 1-576th. Length 1-576th.

C. *Arcus.*—Linear; curved on each side, striated and obtuse; centre of ventral surface not tumid. New York.

C. (?) *acutum.*—Small, slender, slightly bent, smooth (?), acute at each end; on ventral surface, slightly turgid at centre. Habit of *Navicula Amphioxys.*

C. *cornutum.* — Larger, striated, lunate; ventrally gradually tumid at centre; extremities tapering gently, and obtuse.

C. *gracile.*—Linear-lanceolate; straight or slightly curved; convex on dorsum; plane (flat) on ventral; ends slender, subacute,

C. *Leptoceros.*—Long, slender, slightly curved, venter abruptly tumid at its centre; apices attenuate.

C. *Lunula.*—Semi-orbicular; minutely striated; venter plane, dorsum convex; cornua (horns, elongated ends) wanting. Approaches C. *Cistula.*

C. *Mexicanum.*—Large, striated, thick, lunate; venter slightly tumid; ends (cornua) obtuse, and but little produced; eighteen striæ in 1-1152nd., but distinctly and elegantly granular. Length 1-216th. Mexico.

C. *sessile.*—Resembles C. *gibbum*, of which it is but a variety, differing by being attached without a stalk.

Cocconema (?) *Fusidium* = *Cymbella affinis* (Kütz.)—Lanceolate, small, attenuate, subacute at the ends, and smooth; terminal apertures large; transverse striæ distinct, nineteen in 1-1200th. Length 1-1150th. to 1-620th.; living and fossil.

C. *Cretæ* = *Eunotia Cretæ.*—Striated, narrowly lanceolate, very gradually tapering towards each apex, which is acute. Fossil in chalk marl.

Genus Cymbosira (Kütz.)—Individuals either solitary or binate, stipitate; connected in longitudinal rows by a jelly-like band (isthmus.)

This genus is a member of the family *Achnantheæ;* it resembles *Diatoma (Bacillaria,* Ehr.*)* in its mode of concatenation. Its single species is of marine habitat.

C. *Agardhii.*—Linear, arcuate, minutely striated; ends rounded; stalk very short. Length 1-960th. to 1-288th. Found on Ceramieæ and Polysiphonia, at Venice; and in Tropical America. (P. 17, f. 14.)

Genus Doryphora (Kütz.)—Individuals solitary, depressed; secondary side (regularly punctate) elliptic-lanceolate; stipitate. This genus, represented but by one species, is a member of the family *Cocconeideæ* (Kützing.)—The frustules are attached, by one of their produced ends, to a gelatinous stalk.

D. *Amphiceros* = *Cocconeis amphiceros* (Ehr.) — Apices produced, rather acute. Found at Cuxhaven (P. 17, f. 21.)

Genus Echinella (*The palm-like Bacillaria.*)—Simple, attached by a pedicle (stipes), which is either simple or dichotomously branched. Lorica longer than broad, mostly wedge-shaped, and developed by longitudinal self-division, in fan-like clusters. The chief character of the genus consists in the fact of the self-division not influencing the division of the stalk, for the body often divides again without the stalk taking part in the division. During the division of the body, that of the stalk often rests quiet, either periodically, or for ever. Young forms of *Echinella* are with difficulty distinguished from species of *Gomphonema,* and stalkless ones from those of *Synedra,* to which latter their organization closely approaches.

This genus *Echinella* is not recognized by Kützing, who distributes the species enumerated by Ehrenberg, among various genera; retaining, however, the major part of them in the genus *Licmophora,* in

which they were originally placed by Agardh, who constituted that genus.

Echinella *flabellata* (*Exilaria*, Greville).—Smooth and shrub-like; lorica in the form of a truncated elongated wedge, obtusely tridentate, and longitudinally striated. They are attached by the smaller ends to a thick and long stalk, and disposed in a fan-like group. It covers various marine plants or Algæ, as shown (of the real size) in fig. 191; and is of a golden colour. The thick tender gelatinous branched stalks resemble those of *Vorticella*. (See the tree-like group 192.) The stem is an excretion produced by the animalcule, probably like the shells of the Mollusca, like which, too, it is devoid of organic or vital power, and if the fan-shaped bodies separate from it, it evolves no new bodies in the form of gemmæ, but disappears. Group 193 shows a dorsal and lateral view of a single animalcule. Length without stalk, 1-120th; height of tree, 1-12th to 1-6th. On the shores of England, France, &c.

E. *splendida*.—Smooth and branched; lorica rather straight or club-shaped, slender, with rounded capitate ends; dispersed or arranged in fan-like clusters, at the swollen extremities of the branches of a long stem. Length 1-570th; height of tree (frond) 1-140th.

E. (?) *paradoxa* = *Rhipidophora paradoxa* (Kütz.)—Smooth and branched; lorica broadly wedge, or heart-shaped, tridentate and truncate. Found solitary, or mostly in fan-like clusters, upon a slender, filiform, dichotomous stem. Length 1-570th to 1-480th. In salt water, North Sea and Adriatic.

E. *capitata* = *Synedra Ehrenbergii* (Kütz.) — Smooth, stalked, lorica linear, capitate, never wedge-shaped, developed in fan-like clusters, attached to *Hottonia palustris*. Stipes simple, not branched. Length 1-1150th to 1-570th; height of frond 1-280th.

E. (?) *abbreviata*.—Smooth; stipes short and unbranched; lorica cuneate, obtusely tridentate, developed in fan-like clusters. In spring water. Length 1-1150th to 1-860th.

E. *fulgens*.—Striated; pedicle short, unbranched; lorica linear, truncate at both ends, not cuneate. In salt water. Length 1-70th.

Genus Gomphonema. *The wedge-shaped tree-like Bacillaria.*—Lorica simple, cuneate, fixed upon a distinct filiform pedicle; developes by spontaneous self-division, in the form of a dichotomous little tree.

At the broad anterior end are two notches, looking like openings, and one in the centre of both the dorsal and ventral surface. The stalk is an excreted, immovable, horny substance; at its attachment to the lorica there is no opening in the latter; it can detach itself, move about independently, and probably form another stalk. In some instances the lorica appears to be transversely striated internally.

This genus resembles *Cocconema,* but the frustules of the latter are cymbiform, and not cuneiform.

This genus gives name to a family *Gomphonemeæ* in the system of Kützing, which includes, besides, the genera *Sphenella* and *Sphenosira.*

"This genus, *Gomphonema,*" says Mr. Ralfs (Ann. Nat. Hist. vol. xii. p. 459, 460) "borders closely on *Styllaria* and *Licmophora,* and, as it were, forms a connecting link between them. It is only in a young state that, in a few instances, its frustules are sessile, and resemble those of *Styllaria,* which are always sessile . . . . . Its connexion is still more intimate with *Licmophora;* and Mr. Bailey observes, that in *Licmophora* the frustules again divide, which is the sole difference between the two genera." Kützing, however, discovers two points of distinction besides: 1. The presence of a clear central opening on the ventral surface, which is absent in *Licmophora;* and 2. The absence of the longitudinal stripes, which are seen on the dorsal aspect of *Licmophora* near each margin.

"In the wedge-shaped figure of its frustules, *Gomphonema* is assimilated also to detached segments of *Meridon* or of some *Diatoma,* but differs from them in having the central aperture; besides which, its transverse striæ do not traverse the surface unbroken (Ralfs loc. cit.) The frustules situated at the extremities of the dichotomous branches are generally simple, or binate. I have never seen more than six frustules from the same point, and even when more than two are thus occasionally combined, they are usually in contact only at the base. In *Licmophora,* on the contrary, the stipes is irregularly branched, and each branch terminated by several frustules, often ten or more, united by their sides in a fan-like form. Besides these terminal clusters, the main trunks of the stipes have binate or ternate frustules, sessile, or nearly so, along their margins, and either opposite or alternate."

"The notches, like puncta, in the upper margin, are, in some

species, very evident, in others scarcely discernible, and so assist in forming specific characters. There are also two obscure puncta at the base, and generally a single slight notch near the middle of each *lateral* margin. The lateral surfaces are generally transversely striated, and have a longitudinal pellucid line running down the centre."

The species of *Gomphonema* are especially of fresh-water habit, growing on filiform Algæ; but some few are found in the sea; many too, occur in a fossil state, but then only as isolated, detached frustules.

Propagation by conjugation has been witnessed in this family, viz., in G. *dichotomum*, G. *minutissimum*, and G. *constrictum*. (See P. 14 f. 9 to 12, and 17 also.)

Gomphonema *truncatum* (*Vorticella pyraria*, M.)—Striated. Group 187, and P. 4, figs. 188 to 190, represent various views, both separate, and attached; these will convey a far better idea of their form, and the mode of attachment of the genus, than any verbal description. Separated frustules move distinctly. Found free in water and upon Lemna, &c. and fossil, at Franzenbad and San Fiore. Length 1-1720th to 1-280th.

G. *capitatum*. — Striated, elongated, cuneiform, constricted near the wider extremity, forming a short neck, surmounted by a widely-rounded, truncate head. Stipes long, dichotomous, jointed. Length 1-1720th to 1-280th. Occurs both alive and fossil throughout Europe.

G. *Gracile* = G. *dichotomum* (Kütz. and Ralfs.) — Elongated, cuneate; terminal puncta very minute; lateral surfaces lanceolate, faintly striated; stipes slender, much branched dichotomously. The frustules somewhat resemble those of G. *olivacea*, but are larger and narrower, and their puncta far less distinct (Ralfs.) Length 1-1150th to 1-860th.

This and the preceding species form a brownish-yellow slime upon water plants, especially in spring.

G. *acuminatum* = G. *minutum* (Agardh and Ralfs.) — Frustules elongated, wedge-shaped, striated, with a dilated and pointed head or crest, surmounting a constriction; laterally ventricose at the middle. Length 1-860th; sometimes from 1-720th to 1-430th. Found fossil,

and "living on aquatic plants in ponds and ditches, as a brownish mucous fringe. By its terminal crest it resembles G. *cristatum*, but is distinguished from that species by its slender frustules, and their constriction below the apex." (Ralfs.)

Gomphonema *clavatum* = G. *subramosum* (Kütz.)—Smooth, short, and cuneiform; stipes long, very slender, and not much branched. Found living and fossil. Length 1-720th. Cluster 1-120th.

G. *rotundatum.*—Smooth (?), short, cuneate; obovate laterally; stipes long, subramose. Length 1-240th. Living and fossil.

G. *discolor.*—Smooth (?), slightly excised at the wider, truncate end. Length 1-600th. Found in Siberia. Considered a doubtful species by Kützing,

G. *olivacea* = G. *Berkeleii* (Greville and Ralfs.)—Frustules broadly cuneate or triangular, striated; lateral surface obovate, lanceolate; pedicle dense, mucose, short, and entangled, forming a gelatinous pale brown mass. Length 1-2300th to 1-1020th. Common in streams throughout Europe.

The stipes is hyaline and more or less branched; frustules minute, short, triangular, easily detached; puncta at the end strongly marked.

"Var. *b.* (Ralfs.)—Scattered frustules more firmly attached to the stipes, which can be detected without difficulty."

G. *coronatum* (= G. *capitatum*, of Etruria.)—Laterally linear, cuneate; dorsum with four constrictions; the anterior extremity dilated and obcordate, the posterior pointed and lanceolate (P. 17, f. 36.) Length 1-480th. Fossil in the siliceous meal of San Fiore and North America.

G. *Americanum.*—Linear; viewed dorsally, presents three oblong decreasing portions, produced by four constrictions, the anterior end ovate, sub-acute. Length 1-864th. Fossil in North America and Iceland.

G. *Augur.*—Cuneate and linear laterally; dorsally rhomboid, with an acuminate base. Length 1-960th. Among Confervæ from Mexico; alive and fossil also in England and France. The Mexican variety has a mucro terminating the constricted apex.

G. *Anglicum.*—With two dorsal constrictions; anterior extremity rounded, rather more slender than the oblong body, which tapers to a linear apex. Is allied to G. *subtilis.* Ireland and Mexico.

Gomphonema *apiculatum.*—Rhomboid and wedge-shaped ; dorsally, extremities contracted, long; anterior extremity acute (P. 15, figs. 28 and 53.)

G. *Cygnus.*—Narrowly linear-lanceolate, turgid at the middle; anterior extremity obtuse, but long and linear. North America. Kützing thinks this probably identical with *Sphenella rostellata* (Kütz.)

G. *Glans.*—Ovate-oblong, turgid ; anteriorly rounded, and with a slightly narrow neck. It has a general resemblance to G. *clavatum,* but is shorter, stronger, and more obtuse. North America.

G. *laticeps.*—Habit of G. *coronatum* but shorter, and with the anterior end wider than the central part of the body, on the lateral aspect. Iceland.

G. *nasutum.*—Ovate laterally ; the attached or posterior end short and slender ; no neck ; not constricted anteriorly, but furnished with a small point (apiculate.) Approaches G. *Augur,* but is shorter and stronger. New York.

G. (?) *Pupula.*—Linear-clavate laterally ; margin undulate ; striæ few, and appearing like so many constrictions ; apex often narrower than the rest of the body. Possibly a *Meridon.* North America and Iceland.

G. *subtile.* — Slender, dorsum with two constrictions ; anterior extremity small, obtuse, sub-truncate at the extremity of a long and slender neck.

G. *Turris.* — Larger and longer ; anterior extremity elongated, equalling the body in breadth ; its apex suddenly attenuate and wedge-shaped. Approaches G. *gracile,* but is thicker. North America.

G. *Vibrio.*—Linear-lanceolate, elongate ; gradually tapering to the anterior extremity or head, which is subacute and prolonged so as to be sub-rostrate. This species is more slender than G. *gracilis,* and approaches *Pinnularia Amphioxys.* Cayenne.

G. *Herculeanum.*—Very large, minutely striated ; dorsally clavate, with the middle dilated, the ends attenuate and rounded ; becomes slenderer near the pedicle. Pedicles (foot-stalks) long, hyaline, dichotomous. Length of testules 1-216th ; of the compound arborescent being (—arbuscle) 1-12th to 1-6th. Found in Lake Michigan, at Niagara, and in Oregon.

G. *sphærophorum.* — Small, delicately striate ; clavate dorsally ;

apex terminated by a mucro, knob-shaped. Length 1-696th. Alive in Niagara, and fossil at Farmington.

GOMPHONEMA *insulare* (Ehr.)—A new Holland species.

G. *tenuicolle.*—Also a new Holland species.

G. *Palea.*—A fossil species, discovered by Ehrenberg in earth from the Jura range in France.

G. *exiguum* (Kütz.)—Minute, very smooth; on secondary side lanceolate; stalk rather thick, subramose. Length 1-1440th.

G. *minutissimum* (Greville.)—Very minute, quite smooth, linear-cuneate, and curved; on secondary side narrowly lanceolate, striated; stipes slender, subramose. Length 1-2400th to 1-430th. Cluster 1-72nd. England. On Callithamnion in pools and lakes. Its presence gives a yellowish appearance to the water. The terminal puncta are distinct (P. 14, figs. 9 and 12.)

G. *tenellum* (Kütz.)—Small, very smooth, secondary side narrowly obovate; stipes short, simple. Length 1-1440th.

G. *macropus.*—Linear-cuneate, truncate at each end, quite smooth; on secondary side obovate oblong; stipes very short or obsolete. Length 1-1080th. On Vaucheria.

G. *angustum.* — Cuneate-linear, truncate at each end, smooth; on secondary side obovate-lanceolate; stipes elongated, but lost in the aggregated mucous mass. Length 1-720th. Wurzburg and Falaise.

G. *telographicum.*—Minute, and very smooth, slender, cuneate, more acute at the base, dilated at the apex, aggregated on a short stipes branching as a simple close umbel. Length 1-1200th.

G. *digitatum.*—Very minute and smooth, linear-cuneate, flabelliform; stipes simple, dilated. Upward length 1-680th. On Conferva.

G. *abbreviatum.*—Frustules broadly cuneate, conjoined in a flabelliform manner, very smooth, on secondary side obovate, the apex rounded; stipes rather thick. Length 1-1152nd to 1-840th.

Var. *(a) brevipes.* — Stipes very short = *Echinella abbreviata* (Ehr. 1838.)

Var. *(b) longipes.*—Stipes elongate, subramose = G. *rotundatum* (Ehr. 1838.) Common on fresh-water Algæ.

G. *curvatum.*—Cuneate and curved, quite smooth; secondary side, obovate lanceolate (P. 16, f. 11.)

Var. *(a) aquaticum.* — Rather turgid; frustules sub-flabelliform, stipes short, sometimes obsolete. Length 1-720th.

Var. *(b) salinum.* — Slender, stipes elongate. Length 1-720th. It = G. *minutissimum* (Ehr. 1838.)

Var. *(c) marinum.* — Larger; stipes rather thicker, subramose. Length 1-600th. In fresh and salt water.

Gomphonema *subramosum.* — Cuneate, acute at the base, quite smooth; on secondary side obovate; stipes very slender, and subramose. Length 1-1140th. Common on fresh-water Algæ. According to Kützing = G. *discolor* and G. *clavatum* (Ehr.)

G. *lagenula.*—Slender, linear-cuneate, finely striated; on secondary side more acute, and tapering at the base; the apex having a prominent ridge, and being sub-capitate; stipes short. Length 1-720th. In fresh water, Trinidad.

G. *affine* = G. *gracile* (Ehr.)—Rather turgid, elongate, striated; margins on primary side rather curved; on secondary side, sub-lanceolate, end obtuse; stalk short, subramose. Length 1-360th Trinidad.

G. *constrictum.* — Rather turgid, striated; on secondary side tapering at the base, ventricose in the middle, with a short constricted neck, surrounded by a truncate, broadly rounded head; stipes ultimately elongated and ramose. It, says Kützing, = G. *truncatum* and G. *paradoxum* (Ehr.), also G. *pshliæforme*, Ralfs. (P. 16, f. 23.)

G. (?) *contractum.*—Minute, attenuate at the base, constricted in the middle, with a dilated rounded apex; stipes simple, short, or obsolete. Length 1-1440th. On Zygnema. Germany.

G. *intricatum.* — Slender, forming a compact mucous, stratum; frustules, on secondary side, tumid at the centre, much produced at each end, narrow, obtuse; stipes rather rigid, but mucous, and extremely interwoven; its division dichotomous. Length 1-420th. Nordhausen.

G. *lanceolatum.*—Striated, linear-cuneate, very gradually tapering at each end; secondary side lanceolate, with acute ends.

In a note, Kützing observes, that Ehrenberg has described several species omitted by himself—as G. *Cygnus, Vibrio, Turris, Glans, nasutum, coronatum, laticeps, Anglicum, subtile,* and *Americanum,* which

are very doubtful members of this genus, and, more probably, appertain to *Sphenella;* their pedicle (stipes) not having been seen.

The following species and remarks are taken from some valuable papers of Mr. Ralfs (Ann. Nat. Hist. vol. xii. p. 460.)

GOMPHONEMA *geminatum* (Agardh.) — Densely tufted, frustules narrow, cuneate, the puncta at the upper end wanting, or nearly so; lateral surfaces urn-shaped, striated. Found on rocks in sub-alpine streams.

The plant forms tufts of a spongy texture, not at all mucous, composed of the densely woven filaments. In a young state its colour is brownish, from the frustules covering the surface, but as these fall off it becomes whitish, and indeed not unlike a tuft of wool. Filaments are repeatedly dichotomous, frustules of large size, simple or binate. There is a central, longitudinal, pellucid line, slightly dilated at each end, with a larger dilation at the centre, which may be taken for a perforation, which, undoubtedly, it is not. From this central punctum the striæ are somewhat radiant.

G. *pohliæforme* (Kütz.) = G. *truncatum* (Ehr.)—Frustules with two evident puncta at upper ends; laterally, urn-shaped. A very minute species which, to the naked eye, seems only a brownish discolouration of the plant on which it grows. In the more perfect form it resembles G. *capitatum*, as figured by Ehrenberg, nor is there any character in his description to distinguish the latter from this species.

In his last work, Kützing has described this species under the name of *Gomphonema contractum.*

Mr. Ralfs again says, "Ehrenberg appears to have confounded this plant with G. *geminatum* (Agardh), which species, as well as G. *pohliæforme* (Kütz.) (*i. e.*, the immature plant), he appends as synonymous to his G. *truncatum*. If he had seen the true G. *geminatum*, he could not have fallen into this mistake, for, besides the immense difference between these plants in size and habit, their frustules present sufficient marks of distinction. In G. *geminatum* the front view is very narrow, sometimes nearly linear; in this species the frustules are distinctly cuneate, and, notwithstanding their much smaller size, have two evident notches at the upper end, which are wanting in G. *geminatum*. The lateral surfaces, too, are

more attenuated at the base, and they are about as broad as the front, whereas in G. *geminatum* they are much broader.

GOMPHONEMA *cristatum* (Ralfs.)—Frustules crested, lateral surfaces striated, obovate, not constricted beneath the apex; viewed laterally the crest appears like a terminal point. Found by Mr. Jenner on *Conferva glomerata*, near Shoreham, Sussex. It is very minute, the stipes slender, simple, or rarely once divided. It resembles G. *minutum*, (G. *acuminatum*, Ehr.) in its terminal crest, but is smaller, the frustules shorter, and their angles rounded; the lateral view is also broader, and wants the constriction below the apex.

G. *Berkeleii* (Greville) = G. (?) *olivacea* (Ehr.)

G. *minutissimum*. Var. *b*. (Ralfs.)—This variety is more branched than the ordinary plant, and the striæ, extending the length of the frustule from the terminal puncta, are more strongly marked. On marine Algæ. (P. 14, f. 9 and 12.)

This species differs from the other in its curved frustules, in having a notch on one only of the lateral margins, and two striæ passing down the frustule, connecting the upper and lower puncta. Found at Eastbourne, Sussex, and in Ireland.

G. *paradoxum* = *Echinella* (?) *paradoxa* (Ehr.)—Puncta at upper end strongly marked, with a striæ from each passing down the frustule; lateral surfaces clavate, narrow, not striated. It forms a brown, gelatinous covering on the smaller marine Algæ, but turns green on drying. There are no puncta on the lateral margins, and no striæ.

Genus ODONTELLA (Kütz.)—Individuals smooth, rather round but compressed, fasciate in the centre, furnished with two lateral horns at each apex, concatenate, and attached. It is a member of the family *Biddulphieæ*, and all its specimens are marine.

The genus bearing this name, in the system of Kützing, does not correspond with that to which Ehrenberg has attached the same appellation, but mainly represents the *Denticella*, whilst *Odontella* (Ehr.) is a genus of *Desmidieæ* (p. 292.)

O. *subæqua*.—Segments quite smooth, oblong, lateral, horns minute, with no middle process. Among Confervæ, Heligoland.

O. *obtusa*.—Joints quite smooth, but shorter, with turgid, obtuse,

short horns, and a very short central process. Among Conferva, Heligoland (P. 16, figs. 30, 31, 32, 32*a*.)

Odontella *aurita* = *Denticella gracilis* (Ehr.) and *Biddulphia aurita* (Ralfs.)—Very minutely punctate, with a broad central band, extended, slender, acute horns, and a large middle process. Among Algæ, British Coast and Baltic.

O. *turgida* = *Denticella turgida* (Ehr.)—Large, very finely punctate; horns recurved, large, obtuse, and a broad, round, central process. North Sea.

O. *polymorpha* = *Biddulphia lævis* (Ehr.) — Large, with minute, obtuse horns, and no central process.

Genus Oncosphenia.—Lorica simple, quadrangular, cuneate, not concatenate; valves without a central umbilicus, and also destitute of lateral apertures and internal septa; equal, but their apices unequal, on account of their cuneate and uncinate form, *Oncospheniæ* approach nearest to *Podospheniæ,* by the absence of pedicles in the latter, but are peculiar in their uncinate form.

O. *Carpathica.*—Cuneate on the sides and striate; one end straight, turgid, and rounded; the other attenuate and uncinate. Diameter 1-792nd, with eleven pinnules. On the back, their quadrangular figure resembles that of a wand of ten *Bacillaria.* Carpathian mountains.

Genus Pododiscus, (Kütz.) — Frustules single or concatenate, stalked; primary side obsolete; secondary side convex, stipes lateral. It approaches very closely to *Podosira;* but the stalk is placed on the circumference of the disc and not at its centre, as in the latter. It is a member of the family *Melosiræ.*

P. *Jamaicensis.*—Single, or in chains, smooth; stalk long, delicate. Diameter 1-840th. (P. 16, f. 28.) On Algæ.

Genus Podosira.—Concatenate, very distinctly stalked; apparently bivalve, convex, nearly round; stipes central, self-division imperfect, giving rise to moniliform chains. (The two valves are approximated without the presence of any intermediate ring; hence, in Kützing's language, the primary side, as in *Pododiscus,* is wanting—obsolete.) The valves of the two species are very finely punctate. The lorica is soft or horny; the stalk is more developed than in *Gallionella,*

from which it differs also by wanting the intermediate rings between the valves.

PODOSIRA *nummuloides* = P. *hormoides* (Kütz.)—Frustules of a depressed spheroidal form, united by their central pedicles, *(Isthmi)* into a moniliform chain; the stalks are colourless—the corpuscles green and punctate; as many as seven have been seen united. Diameter 1-650th. On Polisiphonia, Callao, Peru. (P. 13, f. 45.)

P. *Montaguei* = *Melosira globifera* (Ralfs.)—Corpuscles elliptic, united by short stalks (*isthmi.*) Diameter 1-600th. Antilles.

Genus PODOSPHENIA.—Simple, wedge-shaped (cuneiform); attached when young by a pedicle, which, however, is sometimes obsolete; they often become free at a later period. The bivalve lorica is longer than broad, with two openings at its broad anterior end; granules yellowish green, scattered mostly when young, but in older specimens united into one or two, often stellate masses. Multiplication is by longitudinal fission. Isolated segments (frustules) of *Merdion* and *Echinella* are liable to be mistaken for those of *Podosphenia;* but the first may be distinguished by wanting, on their surface, the bands (vittæ) indicating internal septa. Kützing's description is "Bacilli on primary side, cuneate; on secondary side, obovate, lanceolate; attached stipes none (or obsolete.)"

In the system of that naturalist, it is a member of the family *Licmophoreæ*; see genus of that name.

P. *gracilis.* — Smooth, narrowly wedge-shaped, rather acute at the base; (fig. 186 shewing a group attached to a thread-like filament, whence they are often mistaken for *Echinella:* but in this case the filament is not part of the creature, but merely the substance to which it has adhered. It often covers Algæ, Vorticella, Sertularia, &c. At the lower part of the group, towards the right side, is represented a side view of one laying across two others, shewn in front view; in the latter, delicate longitudinal striæ are visible, and in the former the upper part of the lorica is rounded.) Length 1-250th to 1-110th. North Sea and Baltic.

P. *abbreviata* =P. *Lyngbyei.*—Smooth, cuneate, broader and shorter than the preceding, base rather acute. Found upon Ceramium diaphanum. (P. 16, f. 13, b.) Length 1-240th. North Sea and Baltic.

P. *cuneata* = P. *Ehrenbergii* (Kütz,)— Striated laterally on the

margin; rhomboidal, club-shaped, and slightly pointed. In salt-water. Length 1-140th. (P. 16, f. 14,) North Sea and Baltic.

PODOSPHENIA (?) *nana.—The dwarf Podosphenia.*—Smooth, linear, cuneate; laterally clavate, without striæ. Length 1-2300th to 1-1720th. Fossil at Bilin.

P. *tergestina* (Kütz.)—Cuneate, triangular; bacilli geminate (in pairs), or ternate, conjoined in a flabellate manner; acute at the base. Length 1-1440th. On marine Algæ, Trieste.

P. *debilis* (Kütz.)—Narrowly cuneate, rather acute at the base, sub-flabbellate. Length 1-1380th. On stems of sea Algæ.

P. *hyalina* (Kütz.)—Cuneate, rather acute at the base, with closely arranged pores (vittæ); laterally, obovate-pyriform; hyaline (P. 16, f. 13a.) Length 1-570th to 1-480th.

Var. *(b.) racemosa.*—Obsoletely stiped. North Sea, Heligoland, England.

P. *tenuis* (Kütz.)—Linear, cuneate, slender, acute at the base. Length 1-480th. Christiana, Sweden.

P. *Jurgensii* (Kütz.)—Broadly cuneate, truncate at the base. Length 1-432nd. On marine Algæ, North Sea.

Genus RHABDOMENA, (Kütz.)—Bacilli tubular, concatenate, stipes lateral, interruptedly vittate, and transversely striated; vittæ capitate; striæ transverse, forming numerous longitudinal rows.

This genus is included in the family *Striatelleæ* (Kütz.); one form only has been previously noticed by Ehrenberg, who has described it as a member, both of the genus *Tessella*, and also of *Striatella, i. e.*, the same form under two names, according to the accidental circumstance of having met with a solitary, free, or an attached frustule.

All the forms of *Rhabdonema* are marine.

R. *minutum* = *Tessella Catena* (Ralfs.)—Small, with a double row of marginal vittæ; transverse striæ very delicate. Length 1-1200th. On Conferva, English Coast; Baltic.

R. *arcuatum* = *Tessella catena* and *Striatella arcuata,* (Ehr.)

R. *Adriaticum.*—Large, with four seriesof vittæ, viz., two marginal and two median; striæ transverse, distinct. Length 1-480th to 1-168th. (P. 16, f. 27.) In Adriatic and Mediterranean.

Genus RHIPIDOPHORA, (Kütz.)—Bacilli, on primary side, cuneate; on the other side, obovate, lanceolate, stalked.

This is a genus of the family *Licmophoreæ*. None of its species have been described by Ehrenberg; they are all inhabitants of the sea, growing on Algæ and other plants. *Rhipidophora* is closely allied to *Podosphenia;* in form it resembles *Gomphonema,* but wants the umbilicus of the latter; and, unlike it, presents bands corresponding with internal septa.

RHIPIDOPHORA *crystallina.*—Shortly stalked, flabellate; bacilli short, cuneiform, rather broad, obtuse at the base. Length 1-1200th to 1-1300th. On Algæ, North Sea.

R. *Ædipus.*—Very shortly stalked, sub-flabellate; bacilli oblong, cuneate, truncate at the base, hemispherical at the stipes. Length 1-600th to 1-480th. Adriatic and England.

R. *australis.*—Flabellate, bacilli narrowly cuneate, truncate at the base; stipes simple, thick. Length 1-540th. Trieste.

R. *borealis.*—Flabellate; bacilli large, oblong, cuneate, slightly obtuse at the base; stipes simple, rather stout. Length 1-310th. Heligoland.

R. *Nubecula.*—Stalk long, filiform, subramose; bacilli hyaline, broadly cuneiform, somewhat acute at the base, scattered, almost solitary, or fasciculate. (1-720th to 1-600th.) Trieste. (P. 16, f. 27.)

R. *tenella.* — Small; stipes slender, very delicately branched; bacilli small, broadly wedge-shaped, conjoined in an imperfectly flabellate manner, acute at the base. Length 1-1080th to 1-960th. On Polysiphonia. (P. 16, f. 15.)

R *Dalmatica.*—Flabellate in a radiating manner; bacilli oblong, cuneate; stipes rather stout, and ultimately subramose, tubular. Length 1-540th.

R. *abbreviata.*—Sub-flabellate; bacilli broadly cuneiform, acute at the base; stipes rather stout, and finally subramose. Length 1-540th. On Ceramium, Palermo.

R. *paradoxa.* — Bacilli short, but widely cuneate, and slightly acute at the base, with obtuse olive-coloured interspaces; stipes slender, filiform, dichotomous. Length 1-540th to 1-480th.

R. *oceanica.* —Bacilli oblong, cuneate, with yellow interspaces, close; stalk long, slender, sub-dichotomous. Var. *(b.)* flabellate. Length 1-390th.

R. *elongata.*—Bacilli larger, cuneate, elongate; somewhat acute

at the base, with obscure interspaces; stipes long, sub-dichotomous, slender. Length 1-310th.

Rhipidophora *superba.*—Larger, slender, and elegant; bacilli in pairs (geminate) or solitary, cuneiform; slightly acute at the base; interspaces (pores) of a golden yellow colour, globose, loosely distributed; stipes filiform, long, dichotomous; secondary branches short and lateral. Length 1-310th. North Sea and Adriatic.

R. *Meneghiniana.*—Large, bacilli geminate, oblong-cuneate; apex rather wide; interstices scattered; globular, brownish olive; stalk very long, with widely spreading dichotomous branches. Length 1-288th. (P. 16, f. 19.) On Algæ, Venice.

R. *grandis.*— Very large; bacilli widely cuneate, with large, globose, granular-looking interstices; stalk very long, with filiform dichotomous divisions. Venice. Length 1-120th. Var *(b.) arachnoidea.* The lateral bacilli mostly caduceous. Length 1-180th to 1-168th. Trieste.

R. *craticula* (Montagne.)—Shortly stiped; stipes slender, dilated at the base, sub-flabellate, craticulate; bacilli, three to six, oblong-lanceolate, truncate, and obtuse at each end. Length 1-650th to 1-450th; wider at the centre than on each side, which is very slightly attenuate. (Ann. d. Sciences, Nat., vol. 14, 1850, p. 308.)

Genus Sceptroneis.—Attached (?) lorica of two equal, styliform, compressed valves, not concatenate; cuneate, (when living, probably pedicellate); a median longitudinal suture on the sides of each valve; no umbilicus. Has the habit of the genus *Meridon,* or of *Gomphonema,* without the lateral umbilicus, and not concatenate.

S. *caduceus.*—Testule bacillar, long, wedge-shaped, with a round turgid head, surmounting a slender neck; turgid at the middle, with granules disposed in rows, and glistening like jewels; the entire form being very beautiful; granules fifteen in 1-1200th. Length 1-192nd, exceeding the width eighteen times. Bermuda.

Genus Striatella, (Ehr.)— *The zig-zag little standard.* Lorica square, tabular, or mostly longer than broad, and without a central opening; attached obliquely by a short lateral pedicle, or foot stalk, and developed in the form of little banners, one end of which often separates (gapes.) (See fig. 203.)

Mr. Ralfs thus defines Striatella: "Filaments attached by stipes,

frustules cohering by the angles, longitudinally striated. Differs from *Achnanthes*, by its frustules cohering at their angles, and having longitudinal striæ. It differs from *Tessella* only in the stipitate filaments.

"The two series of longitudinal striæ in *Striatella* exist also in *Tabellaria*, *Tessella*, and *Tetracyclus*. The appearance of longitudinal striæ is in fact produced by siliceous plates, arising internally from the margins of the filament, and extending towards, but not reaching the centre. The interior is thus divided into chambers, opening into a central space. When viewed laterally, this central space has the appearance of a canal, especially as the inner edge of each plate has a concave outline."

The genus *Striatella* of Kützing, does not correspond with that of Ehrenberg; it is represented but by one species, S. *unipunctata*, which = *Tessella arcuata* (Ehr.) The genus is thus defined:—

"Bacilli tabulate (longitudinally vittate), vittæ pervious, numerous, dense, band-like, stipes lateral."

In the notes on S. *unipunctata*, Kützing says: "The tables (bacilli) are mostly single, rarely conjoined; large and small forms are often collected together. The stipes is not always to be found, and may be easily overlooked on account of its translucence. The chain-like forms represented by Greville, I have not seen; and they probably rather belong to the genus *Hyalosira*." *Striatella* gives name to the family *Striatelleæ*, which includes also the genera *Tessella*, *Hyalosira*, and *Rhabdonema*.

Striatella *Thienemanni* = *Tetracyclus lacustris* (Kütz.)—Testules elegant, closely resembling those of *Striatella arcuata*, but gibbous laterally at the middle. Found by Ehrenberg in earth, from Iceland; also living, in England and Wales.

S. *arcuata* = *Rhabdonema arcuatum* (Kütz.)—*The curved striatella.* Tabular, nearly square, having from three to seven internal longitudinal lines transversely striated. The clusters of banners form curved ribbons; granules yellow at first, but become reddish or violet. Fig. 203 represents two and-a-half tablets, with dispersed granules; and fig. 204, an old one with them united. Length of single lorica 1-570th to 1-200th. On marine Algæ.

STRIATELLA *unipunctata* (Ag. and Ralfs.)—Stipes slender, much longer than the frustule, which has several longitudinal striæ. Filaments minute, pale yellowish-brown, consisting of but few frustules, which cohere at the alternate angles; lateral surfaces lanceolate, without striæ.

S. *teniæformis* (Ralfs.)—Longitudinal series of transverse striæ in some specimens more or less evident on the central portion of the frustules; in others, the longitudinal striæ, extending from the end towards the middle, are serpentine; stipes short.

Var. (*a.*)—Frustules without transverse striæ. Common.

Var. (*b.*) *striata.*—Frustules with longitudinal series of transverse striæ on each side, having a single curve near the base. Torquay.

Var. (*y.*) *serpentina.*—Frustules with longitudinal series of transverse striæ; the longitudinal striæ on each side undulated; also a narrow longitudinal space without any markings. Torquay, Hastings.

Genus SYNEDRA.—*The yard or ell-measure Animalcules.*—Are, when young, attached by one extremity; at a later period, often free. Lorica longer than broad, of the form of a wand (bacillus), prismatic, destitute of a distinct foot or neck-like process, or at most it is rudimentary; simple, (smooth or striated), with openings at the ends, but none in the middle; the cluster of ova (granular mass) is sometimes divided into from two to four leaf-like plates, or into purses or lappets; digestive cells have not been observed.

This genus Kützing arranges in his *Surirella,* and thus defines it. Individuals bacillar, prismatic, rectangular; ultimately attached by one or other extremity; secondary side equal to or less than the primary, traversed by a very smooth median longitudinal line (no central aperture). This last circumstance distinguishes *Synedra* from *Navicula.*

The number of known species being very considerable, Kützing has distributed them in six sections, viz: 1. *Scaphularia,* minute, rarely attached and smooth forms. 2. *Echinaria,* smooth and finally attached forms, mostly aggregated in a radiant manner. 3. *Ulnaria,* attached, dividing in a flabelliform mode; transversly striated, save at the centre. 4. *Tabularia,* affixed horizontally to a growing stipes and dividing in a tabellate manner. 5. *Grallatoria,* with a long often

ramose stipes; bacilli generally in pairs, and smooth. 6. *Rimaria*, connate in tables, at length separating, except at their alternate angles, where they cohere.

Synedra *ulna (Vibrio bipunctatus*, M.)—Striated; truncated laterally; as age advances the lateral ends become dilated; upon the broad side of the dilated end are seen three obtuse teeth, and two openings between them. Often occurs in vast numbers, appearing as a white incrustation, covering the stones on the banks of rivers in summer. Dr. Lankester has noticed this in the Annan, Dumfriesshire; wherever a mass of gravel was exposed to the air, the surface of the stones appeared thus covered. With a pocket magnifier, they resembled acicular crystals; using a deeper power and examining the wet stones on the edge of the water, they were mostly arranged in a stellate form, resting upon filaments of Conferva. Size 1-100th long, 1-2000th broad. Dr. L. says, the lorica of those from the Annan is not striated, nor are their ends dilated.—*(Proc. Lin. Soc.)* Sometimes they are parasitic on Vorticella, or may themselves serve as a basis for the attachment of other beings, as the Podosphenia (f. 184); so that we have here an example of one parasite growing upon another. Found both in fresh and brackish water. Size 1-280th to 1-100th.

S. *sigmoidea.* — Striated; large, slender, and sigmoid. *Group* 148 shews to the left a specimen undergoing longitudinal self-division; the figure on the right is a side view. The relation of the length to the number of stripes is as follows:—Those individuals which were 1-720th long had ten stripes; 1-570th, fourteen; 1-480th, fifteen; 1-360th, twenty; 1-280th, twenty-seven; 1-140th, fifty-four; 1-120th, sixty; 1-70th, one hundred and eight; 1-48th, one hundred and sixty; 1-36th, two hundred and sixteen.

S. *capitula.*—Very large, striated, linear, straight, of the form shewn in group 185, which exhibits both a front and a side view; granules yellowish green. Common, both living and fossil. Length 1-120th to 1-40th.

S. *Gallionii.*—Large, bacillar, smooth, linear and attenuate laterally; margin striated; stipes thick and curved. Length 1-120th to 1-100th (P. 15, f. 34, 36). Marine.

SYNEDRA *fasciculata.*—Smaller, smooth, attenuated near the extremities, which are sub-acute; laterally linear. In front view, elliptic lanceolate, marine, growing on sea weeds. (1-800th to 1-480th.)

S. *lunaris.*—Smooth, arcuate (curved), obtuse, linear, aggregated in a radiating form, affixed to Conferva, &c., but sometimes isolated and free. Length 1-430th to 1-280th. Common in fresh water.

S. *bilunaris.*—Smooth, with two curvatures (bilunate) resembling two lunate bodies attached end to end, base tapering, apex dilated and obtuse. Length 1-570th.

S. *gigantea.*—Very large, linear, striated laterally, each end suddenly rounded, dorsally apices attenuate, sub-acute; surface very finely striated in the intervals of the pinnules. Length 1-60th. Oasis of Jupiter Ammon, Africa.

S. (?) *Australis.*—Linear, striated ends on every side, attenuate, obtuse. Length 1-432nd. In siliceous schist from the Phillipine Islands.

S. *Hemicyclus.*—Small, linear, semi-circular, obtuse, with transverse striæ. Length, diameter taken in the length of its curve, 1-1152nd to 1-864th. Fossil in Sweden. Is it a fragment of others?

S. *paleacea.*—Very narrow, smooth; apices sub-acute. Length 1-480th. In siliceous earth from the Phillipine Islands. If a *Podosphenia?* or *Fragilaria?*

S. *amphirhynchus.*—Linear, striated dorsally; extremities constricted, sub-acute, rostrate; no median, hyaline, smooth band. Length 1-120th to 1-96th. Fresh water. Egypt, Mexico.

S. *Entomon.*—Elongate, thick, striate; oblong on the sides, constricted at the middle and obtusely cuneate; dorsally, broadly linear and truncate.

S. *gibba.*—Long, linear, narrow, smooth, fasciculate; laterally widely expanded at the centre, ends gradually tapering, obtuse. United States.

S. *lævis.*—Smooth, shorter, but narrowly linear, equally slender throughout, ends gradually tapering, sub-acute. Length 1-130. On marine Algæ.

S. *scalaris.*—Broadly linear, large; sides straight, ends truncate, rounded; delicately striated between the pinnules. Length 1-288th. Surinam.

Synedra *valens.*—Very large, widely linear, minutely pinnate, ends truncate (P. 15., f. 44).; approaches *Echinella fulgens.* Fresh water. Mexico and New York.

S. *incurva.*—Linear, but flexuose, smooth, and very narrow, with four equal sides (if rounded). Length 1-288th. The apparent double margin may indicate the canal of a Spongolithis. If a Spongolithis? (a genus of Phytolitharia). Bermuda.

S. *longiceps.*—In form approaches nearly S. *capitatum,* but has its ends elongated and styliform. Length 1-12th to 1-144th. Living in Lake Michigan.

S. *spectabilis.*—Large, widely linear, with one apex cuneate truncate, the other rounded. Chili, Mexico, United States, Bosphorus, &c.

S. *sigmoidea.*—A New Holland species, discovered by Ehrenberg.

S. *quadrangularis* (Kütz), very small; on one side very narrowly linear, on the other wide, and sub-obliquely quadrangular. Length 1-2880th. On Conferva. Coast of Norway.

S. (?) *minutissima.*—Very minute; on one side narrowly linear, on the other (*dorsum,* Ehr.) lanceolate and rather obtuse. Length 1-2400th. On the shore at Ferrara, on Oscillatoria.

S. *perpusilla.*—Very small; narrowly linear laterally, dorsally lanceolate and contracted near the obtuse ends. Length 1-2400th. Venice.

S. *biasolettiana.*—Very small; laterally narrowly linear and curved; dorsally obtusely lanceolate. Length 1-2640th. On Oscillatoria at Trieste.

S. *Pusilla.*—Small; laterally widely linear, dorsally oblong, elliptic, with obtusely rounded apices. Length 1-1800th. On Oscillatoria, Carlsbad.

S. *Frustulum.*—Small, linear; laterally truncate; dorsally cuneate, acute; imbedded in a gelatinous mass. Length 1-1320th. It forms a green stratum on rocks in Italy.

S. *Palea.*—Small; laterally, narrowly linear; dorsally wider, but narrowly lanceolate and acute. Length 1-650th. On Oscillatoria, Trieste, &c.

S. *acicularis.*—Small laterally, very narrowly linear; dorsally lanceolate, much prolonged (acuminate). Length 1-350th.

S. *angustata.*—Laterally narrowly linear; dorsally wider, oblong,

attenuated towards each end, which is rather obtuse. Length 1-720th.

SYNEDRA *virginalis.*—Laterally linear, oblong, truncate, contracted at the middle, dorsally lanceolate. Length 1-600th. Genoa.

S. *constricta.*—One side wider, constricted at the centre, acute at each end; the other more narrow, linear-lanceolate, and rather obtuse. Length 1-540th. Venice.

S. *parva.*—At first seen freely swimming and solitary, but at length becomes attached and aggregated with others in a densely radiating manner; laterally linear, truncate; dorsally wider, lanceolate, acute. Length 1-1200th. In ponds free, or attached to other Diatomeæ.

S. *dissipata.*—Slender; laterally narrowly linear, truncate; dorsally lanceolate, acute. Length 1-1140th. It probably=S. *fasciculata* (Ehr).

S. *subtilis*=*Navicula acus* (*Ehr*).

S. *Famelica.*—Delicate; narrowly linear, irregularly aggregated; on one side rather acute, on the other truncate. Length 1-1020th. On fresh water Algæ. Halle, Germany.

S. *radians.*—Delicate; very narrow, linear, very densely aggregated in a radiant form; on one side truncate, on the other attenuate and slightly obtuse. Length 1-600th.

S. *gracilis.*—Slightly attached, scattered; laterally linear, apices tapering but truncate; dorsally lanceolate, pointed, acute. Length 1-360th to 1-240th. Marine.

S. *Fusidium.*—Scattered; laterally linear, slightly attenuated at the ends; dorsally lanceolate, and somewhat acute. Length 1-720th. Fresh water.

S. *amphicephala.*—Slender, weak, very narrow; laterally perfectly linear, truncate, dorsally tapering to the ends, which are expanded (capitulate). Length 1-360th. Fresh water, Thun.

S. *tenuissima.*—Very slender and narrow, elongated; laterally perfectly linear, truncate; dorsally tapering to acute ends. Length 1-180th. Fresh water.

S. *tenuis.*—Long, slender; truly linear and truncate, laterally; dorsally, gradually tapering towards each end, which is rather obtuse. Length 1-168th. Fresh water.

S. *acicula.*—Long and slender, sides gradually tapering to the ends,

which, viewed laterally, are truncate, and dorsally very acute. Length 1-72nd. In ponds. Dalmatia.

SYNEDRA *curvula.*—Long, slightly curved; laterally rather tapering towards the truncate end; dorsally acuminate, with somewhat acute apices. Var. *b.* Testule longitudinally dotted. Length 1-240th. Fresh water.

S. *Arcus.*—Laterally linear, truncate, and curved; dorsally straight, lanceolate, with acute ends. Length 1-420th. Gulf of Genoa.

S. *debilis.*—Small, linear, margin indistinctly striated; dorsally produced into a point; laterally rather attenuate and truncate Length 1-620th.

S. *notata.*—Small, with the margin obsoletely striated; laterally oblong, truncate; dorsally elliptic, long, with the apices almost round and obtuse. Length 1-650th.

S. *Martensiana.*—Smaller, distinctly striated; laterally linear, truncate; dorsally lanceolate, gradually tapering, and somewhat acute. Length 1-600th.

S. *Vaucheriæ.*—Small, very delicately striated; truncate laterally; dorsally attenuated near the apex and acuminate. Length 1-780th.

S. *lanceolata.*—Rather small; dorsally lanceolate, distinctly striate; marked by a transversely median rhomboid and perfectly smooth band; laterally narrowly linear, slightly attenuate at the middle. Length 1-600th to 1-310th.

S. *acuta.*—Large; laterally, perfectly linear and truncate; dorsally, suddenly acuminate near the apex. Length 1-144th. Trinidad, Peru, Mexico, Chili.

S. *oxyrhynchus.*—Large, linear; dorsally narrowed towards the apex, which is acuminate. Length 1-280th to 1-144th.

S. *tergestina.*—A variety of *S. Ulna,* presenting laterally a sigmoid form. Trieste.

S. *mesolepta.*—Delicate, linear; laterally attenuated near the middle; dorsally slightly bent, sometimes subsigmoid, gradually acuminate. Length 1-160th.

S. *equalis.*—Large, linear; laterally, dilated at each extremity; dorsally, with the apex rather tapering, but obtuse and rounded. Length 1-140th.

SYNEDRA *vitrea.*—Large, linear; laterally, dilated at each end; dorsally, suddenly attenuated at the ends, which are slender but obtuse.

S. *praemorsa.*—Large, widely linear; laterally, with cuneate, truncate ends; dorsally, with wedge shaped, rounded ends.

S. *Danica.*—Large, weak; laterally with the ends dilated and truncate; dorsally tapering on each side from the centre towards the apex, which is dilated, round and obtuse. Length 1-140th.

S. *splendens.*—Very large, elongate; laterally dilated at each end, which is truncate; dorsally tapering from the centre gradually to each of the rather obtuse ends. Length 1-72nd.

S. *Biceps.*—Large, dorsally curved near the ends, and constricted so as to form a rounded head. Length 1-100th to 1-60th.

S. *Armoricana.*—Large, turgid; laterally widely linear, sigmoid, truncate, the margin having glandlike (dotted) striæ; dorsally, narrowly linear, straight, apices attenuate and rather obtuse. Length 1-108th.

S. *sigmoidea.*—(Kütz) = *Navicula sigmoidea.* Ehr.

S. *vermicularis.*—Small, slender, linear, truncate, sigmoid and smooth. Length 1-200th.

S. *sigma.*—Rather small, sigmoid, each end slightly attenuate, truncate margin delicately striated. Length 1-140th.

S. *parvula.*—Small, narrowly linear, smooth; laterally truncate at the apices, dorsally narrowly lanceolate. Length 1-960th.

S. *Acus.*—Smooth, slender, of moderate size; laterally, rather attenuate towards the truncate ends; dorsally, very narrowly lanceolate or acicular. Length 1-260th. Hamburgh.

S. *familiaris.*—Rather small, smooth, very distinctly tabulate and broken up in a flabellate (whiplike) manner, laterally rather tapering towards the truncate ends; dorsally lanceolate, acute. Length 1-320th.

S. *pulchella* = *Exilaria pulchella* (Ralfs)—Rather small, tabular, expanding in a flabellate manner from the point of attachment; laterally smooth, attenuate towards each end, which is truncate; dorsally narrowly lanceolate. Length 1-360th.

S. *Mucicola.*—Imbedded in mucus, wands smooth; a few conjoined in a flabellate manner; somewhat attenuate towards each end, ends truncate. Length 1-650th.

SYNEDRA *arcus* (Kütz.) = *Eunotia Faba.* (Ehr.)—Rather small, with a distinct convex stipes; wands smooth, laterally linear, sub-attenuate, curved; dorsally linear-lanceolate. Length 1-300th. Valpraiso and Falkland Islands, on seaweed.

S. *Barbatula.*—Tabulate; small; wands exactly linear, truncate; apices with a mucous appendage (barba); dorsally elliptic-lanceolate. Length 1-960th. Marine.

S. *fasciculata.*—Small, tabulate, stipes thick, hemispherical; bacilli linear, subattenuate at the apex, and truncate; dorsally elliptic lanceolate. Length 1-480th.

S. *tabulata.*—Large, tabulate, stipes short, bacillar, broadly linear, tapering towards the ends; laterally truncate; dorsally rounded obtusely. Length 1-130th to 1-120th.

S. *affinis.*—Rather smaller, tabulate, stipes hemispherical; bacilli hemispherical; bacilli in pairs, or in fours, often disposed in a circular form, slender, linear, sub-attenuate and truncate at the ends; dorsally narrowly lanceolate. Length 1-320th. Adriatic Sea, Venice, Trieste, Spalato.

S. *Saxonica.*—Rather small, slender, linear, laterally truncate at the ends, dorsally narrowly lanceolate; stipes rather long. Length 1-330th.

S. *Ehrenbergii* = *Echinella capitata* (Ehr.) — Largely stalked, bacilli capitate; attenuate towards each end, which is round and obtuse.

S. *Dalmatica.*—Large, stipes eventually long and subramose, the branches bearing the wands near their extremities; bacilli linear, rather attenuate towards each end, which is rounded and truncate. Length 1-240th.

S. *superba.*—Large, turgid, stipes but little elongated; bacilli rather thick, widely linear, attenuated towards the ends; laterally truncate, dorsally narrower, ends rounded and rather obtuse. Length 1-120th to 1-84th. Marine.

S. *crystallina.*—Very large, striated, glistening like silver, when dry; crystalline, stipes short and thick; wands very long, somewhat turgid, linear, ends truncate; dorsally with obtusely rounded ends. Length 1-60th to 1-48th.

S. *gigantea* (Kütz.) — Very long, delicate, and rather twisted,

stipes short, bacilli exactly linear, with truncate ends: margin very smooth, dorsally very narrow, dilated at the ends into obovate small heads. Length 1-48th. Coast of Dalmatia. This differs much from the species so named by Ehrenberg.

SYNEDRA *rumpens.*—Attached in a tabulate manner, tables at length breaking up; wands very narrowly linear, rather tumid, and obtuse at the ends; cohering by alternate angles. In brackish water. German coast.

Sub-section III. LACERNATÆ. *Compound Naviculæ.*—

The individual siliceous frustules, or loricæ, are themselves included in a gelatinous mass; hence Ehrenberg views them as having a double lorica, or as compound forms, in contra-distinction to the rest of the *Naviculacea,* which are in his nomenclature called simple.

Genus BERKELEYA (Grev.)—"Frustules linear, included within tubular, sub-membranaceous filaments, which are free at one extremity, but have the other immersed in gelatinous tubercle." (Ralfs, Ann. Nat. Hist. v. 16, p. 110.)

"This genus differs from *Homœocladia* and *Schizonema,* in having the base of the filaments immersed in a tubercle." It belongs to Kützing's family, *Naviculeæ,* sect. *Schizonemeæ.*

B. *fragilis.*—Filaments hyaline, sub-simple, minute; frustules numerous, crowded, lanceolate, or linear-lanceolate, eight to twelve times as long as broad, ends truncate, in length 1-360th., not striated.

"When recent, the plant is dark olive-brown with a slight lustre; when dried is greener, and generally glossy. Filaments very short, seldom exceeding a quarter of an inch in length, and pale at their immersed base, from which they issue in a radiate manner; usually simple, but occasionally dichotomous. The tubercle is colourless, gelatinous, large in proportion to the size of the plant. Parasitic on *Zostera marina,* and smaller sea Algæ. British Coasts."

B. *Adriatica* (Kütz.)—More loosely branched; the branches with distinct subdivisions; frustules narrowly linear-lanceolate, and rather obtuse. Length 1-300th. Trieste, Adriatic Sea. (P. 17, f. 34, 35, *a. b.*)

Genus DICKIEIA (Ralfs.)—Frond sub-gelatinous, tender, plane, attenuated toward the base, undulated; containing oblong frustules,

(navicular bodies) scattered single, or in pairs, with a circular spot at the angles.

"Frond extremely tender, it tapers at the base and expands upwards into a lanceolate or obovate form. I could detect neither striæ nor puncta in the frustules, which in the front view are nearly quadrate, and are rarely twice as long as broad; in the lateral view they are narrow linear, with rounded ends; as they do not appear to be siliceous, it is probable that dried specimens become in that view somewhat narrower than they are when recent; a fact, which I have noticed in some genera of this order, whose frustules cannot, without injury, be submitted to the action of nitric acid.

"*Dickieia* differs from *Schizonema* by its flat fronds and scattered frustules. (Ann. Nat. Hist. 1858, v. 1.)

Dickieia *Ulvoides.*—Of a pale purplish-white colour; olive when dried; stalk very slender, capillary, short, frond oblong, irregularly lobed, or crenate; tapering gradually to its base; navicular bodies rather broad, oblong, in pairs, angles obtuse, and apices truncate. Length of navicular 1-720th., of frond one-and-a-half inch. Found on the Coast of Aberdeen, in the Spring. (P. 24, f. 31, *a, b, c, d,* and *e.*)

"D. *pinnata.*—Found sparingly, pinnate, all the divisions lanceolate.

"Fronds olive-brown, becoming greener when dried, one to two inches high, lanceolate, irregularly pinnate; the pinnæ lanceolate and alternate; the margins, both of the primary portions and of the divisions, are uneven and minutely lancinated. The frustules are like those of the preceding species, from which it differs by its darker colour, divided frond, and more tapering extremities, and in being an autumnal, not a vernal species. In shallow marine pools, Torquay."

D. *Dansei* (Thwaites, Ann. Nat. 1848.)—Frond gelatinous, indefinite, mammillose; naviculæ oval, striated. (P. 24, f. 30, *a, b.*)

The frustules of this species are siliceous and of an oval form, with a linear space, on either side of the central band, striated. This beautiful new species is extremely interesting, as illustrating the real structure of *Dickieia*. Each frustule developes around itself a definite amount of gelatine, so that at each repetition of fissiparous division additions are made to the amount of gelatine of the frond by the new frustules, which are then produced. In the present

species these additions are in the form of mammillæ, and a good deal resemble the mucous prolongations of some of the *Palmelleæ,* a frustule being situated towards the extremity of each. A mammillose and somewhat areolate appearance is thus given to the indefinite frond, whereas, in D. *ulvoides,* the newly developed additions to the gelatine cohere to form a compact, even membrane.

This species is named after its discoverer, Mr. Dansey, who finds it in small quantity upon rocks on the tidal shore of the river Tamar.

In a paper published by Mr. Ralfs, subsequently to that by Mr. Thwaites, with the foregoing details, the former gentleman writes:—

"DICKIEIA *Danuseii* (Thwaites) does not belong to this genus, since its gelatinous matrix forms an irregular mass, and not a plane frond. Its frustules also differ, being decidedly siliceous, striated, and having a longitudinal pellucid line and central punctum (aperture, Kütz.) in the lateral view."

Genus ENCYONEMA (Kütz.)—Cymbellæ (frustules) disposed in longitudinal rows, included in very soft, simple, gelatinous, tubular filaments, (colourless under the microscope.)

This genus belongs to the family *Cymbelleæ,* of Kützing; it was confounded by Ehrenberg with *Gloeonema.* It (Ralfs Ann. Nat. Hist. v. 16, 1843, p. 11) "differs from *Schizonema,* and other frondose genera of *Diatomaceæ,* in the form of its frustules, as a single frustule resembles one of *Cymbella* or of *Cocconema*; therefore, notwithstanding the similarity of habit, it belongs to a different series."

"Certain bodies of a totally different kind have been mistaken for examples of this genus, especially congeries of ova of different insects; but these ova, although cymbiform and arranged in longitudinal series, are neither siliceous nor striated.

"The lateral surfaces of the frustules being convex, are observed in the front view, in which also the frustules are quadrilateral, with two puncta at each end. These puncta are less easily discerned in the dorsal view, as the dorsum is longitudinally convex. The lateral view is semi-elliptic, with numerous transverse striæ, which are interrupted, as in *Cocconema,* by a longitudinal pellucid line."

Kützing describes two species: "but (says Mr. Ralfs,) I doubt

whether they are sufficiently distinct, as I find that the form of the frustules varies even in the same specimen."

ENCYONEMA *paradoxum* (Kütz.) = *Gloeonema paradoxum* (Ehr.)—Tubules scattered, solitary; frustules on secondary side acuminate, horned, and striated. Length of frustule 1-660th. Parasitic on Conferva, Germany, Italy, Falaise, &c.

E. *prostratum* = *Schizonema prostratum* (Grev.)—Forms a gelatinous stratum; tubules very much interwoven; frustules smaller, rather obtuse, not horned, striated. Length of frustule 1-996th. Italy, England, &c. (P. 17, f. 22.)

(Ralf's Loc. Cit.) The tufts, when recent, are dark brown, but of a dull green colour when dried. It is soft, but not gelatinous, adhering only imperfectly to paper or glass.

The filaments are short, straight, or flexuose, simple, or slightly branched, slender, subequal; quite colourless under the microscope. Generally, the frustules form a single series, and have their convex margin alternately in opposite direction.

Genus FRUSTULIA.—Characterized by a double envelope, the loricæ being enveloped, and either scattered or grouped together in an amorphous gelatinous mantle, or lacerna. The true lorica has six openings, two at each end, and two in the middle. The ova cluster is divided into from two to four leaf-like portions; digestive cells and bright glandular organs are often visible. This genus is closely allied to *Navicula*. No figure is given in *Die Infusionsthierchen.*

It is admitted by Kützing, in his family *Naviculeæ,* under the section *Schizonemeæ;* but *Frustulia appendiculata* is excluded.

F. *appendiculata.*—Lorica (navicular bodies) straight, lanceolate, and smooth (?) with obtuse ends, scattered in the gelatinous envelope. Lorica like that of *Navicula gracilis,* but rounded on the dorsal and ventral surfaces, and more parallel on the lateral ones. The central opening is broad transversely, terminal foramina round, self-division often observed. Mineral springs of Carlsbad. Length 1-800th to 1-1150th.

F. *maritima.*—Smooth (?); ends rounded, combining in groups, in contiguous, but distinct, gelatinous cells. Length 1-1200th to 1-1150th. Alive in sea-water.

This species occurs as a brownish jelly-like mass on stones, and

other substances in sea-water. In the gelatinous cells, Ehrenberg observed from one to twenty navicular corpuscles.

FRUSTULIA *salina.*—Transversely striated, very narrowly linear, straight, suddenly acute at each end in one aspect, but in another rounded; densely distributed within the gelatinous investment. Length 1-2300th to 1-860th. In saline springs, Germany.

Genus GLOEONEMA (Ehr.)—Has a double envelope, the inner one, or true lorica, curved and siliceous; outer one combustible, tubular, often branched, and containing many individuals. The enclosed bodies multiply by self-division, and in habit approach *Navicula,* or more nearly *Cocconema.*

This genus is not admitted by Kützing, who charges Ehrenberg with producing confusion, both by stating the *Encyonema paradoxum* of his synopsis to be synonymous with *Gloeonema paradoxum* (Agardh), and by describing it under this name, when, indeed, the species so-called by Agardh was not a member of the family *Diatomeæ* (see *Encyonema.*) This so-called *Gloeonema* of Agardh, indeed, has been determined by Mr. Berkeley to be nothing less than the eggs of an insect, with a common connecting mucous investment of a tubular form.

G. (?) *triangulum.* — Corpuscles navicular, unequal, dorsum gibbous, approaching a triangular form laterally. Diameter 1-782nd. Alive at Niagara. "I have not met with continuous tubules, but have seen it associated with G. *paradoxum,* the tubules of which were present along with scattered corpuscles of a similar character." Bailey.

G. *sigmoides.*—Corpuscles oblong, linear, flexuose, sigmoid, acute, striated, enclosed in gelatinous, simple tubules, in single rows. Length 1-1300th. Living in Demerara.

G. *sinense.*—Corpuscles oblong, striated; apices abruptly reflexed after the manner of many *Eunotia.* Length 1-576th.

G. *paradoxum* = *Encyonema paradoxum* (Kütz.) — Semi-ovate, curved, striated, inclosed in hyaline, simple or rarely branched tubes. Ehrenberg remarks, "I found this species very abundantly amongst *Mytilus polymorphus,* upon *Conferva rivularis,* and saw both simple and branched threads; the little bodies, or corpuscles, being seldom arranged in two rows, but mostly in one. It is a very remarkable circumstance that I very often found two different sorts of these

Navicula-like bodies in the same tube; one, very delicate and straight kind, evidently a *Naunema;* the other the large curved kind. Even to the present moment, I cannot explain this phenomenon, for both sorts were in considerable quantities, and quite free, and therefore it is difficult to suppose one a parasite." Size 1-2300th.

Genus HOMOEOCLADIA (Agardh.)—Compound frond, membranous, filiform, branched, transversely wrinkled, composed of gelatinous tubes, containing bundles of linear, elongated, navicular bodies, densely aggregated.

This genus is included by Kützing in his great family *Naviculeæ.* In Ehrenberg's arrangement, it falls, with *Schizonema* and other genera, under that section, which he describes as possessing a double envelope.

H. *pumila.* — Branches equal, obsoletely jointed, capillary, irregularly divided; navicular bodies linear, shortened, with rounded apices (P. 17, f. 37, 38.) Length 1-408th. In the Adriatic Sea.

H. *moniliformis.*—Capillary, arranged in a head (coma, like that of a tree), with slender branches, long and moniliform; collections of naviculæ with wide intervals; naviculæ very long, linear, and obtuse. Length 1-276th. Adriatic Sea, Trieste.

H. *anglica.*—Umbellate at the base, setaceous, di- or seldom trichotomous; branches equal, acute at the extremities; bundles of naviculæ closely approximate, naviculæ very long, perfectly linear, obtuse; lateral surfaces transversely striated. Length 1-84th. Coasts of England and France. It is brownish when recent, and of an opake olive brown when dry. Frond one to two inches high.

H. *maritima.*—Comose, setaceous; terminal branches corymbose, acute; fasicles of naviculæ closely set; naviculæ very long, narrowly linear, obtuse, transversely striated. Length 1-96th to 1-8th. On stones in the Gulf of Venice (P. 17, f. 47, 48, 49.)

H. *Arbuscula.*—Much branched, branches fasciculate; the lower ones setaceous, the upper capillary, falsely jointed; naviculæ linear, rather wide, but elongated, obtuse, and quite smooth. Length 1-7th, Venice.

H. *dilatata.*—Much branched, very setaceous, branches pointed, thickened upwards; in clavate closely set bundles; naviculæ linear, elongated, circular, obtuse. Length 1-12th. Trieste.

Genus HYALOSIRA (Kütz.)—Frustules (bacilli) tabular, quadrate, in chains, stipitate laterally, interrupted by vittate; vittæ alternating, connected by very fine lines with the centre. It belongs to Kützing's family *Striatellæ.* All the species are new. (This and the two following genera belong to sub-sec. 2.)

H. *minutissima.*—Shortly stalked, concatenate, segments quadrate, half detached from one another, very small. Length 1-5700th.

H. *delicatula.*—Shortly stalked, concatenate; segments quadrate, half detached, minute. Length 1-2640th.

H. *rectangula.*—Shortly stalked, concatenations imperfect, segments sub-quadrate, rectangular, larger (P. 17, f. 23.) Length 1-1380th.

H. *obtusangular.* — Stipes long, filamentary or sub-concatenate; segments quadrate, angles obtuse, large (P. 17, f. 29.) Length 1-1440th. On Bryopsis, Venice.

Genus ISTHMIA.—Frustules combined so as to form irregularly and imperfectly branched filaments, attached; frustules trapezoid or rhomboid, cellulose, oblique, articulated to each other by a short neck-like process—*isthmus*—near which an apparent pore is observable. Division obliquely transverse. Lorica siliceous, undestroyed by heat or acid.

"Frustules always more or less oblique; the adherent (basal) frustule, the isthmus forms the stipes. The frustules are turgid, and the reticulations of the central portion smaller than those of the sides. On each side of this central portion are seen the lateral surfaces, with their reticulations and striæ arranged transversely. As these lateral surfaces are turgid and compressed, they appear, at first sight, to form part of the front of the frustule. This may be observed in some slight degree in *Diatoma vulgare.*" That such however is not the case "will be found, on a careful examination of the exterior; but it is still more evident on a view of the interior of a fractured frustule, when the junctions of the sides, with the central portion marked externally by mere lines of separation, form internally projecting plates or rims."

"This genus is easily distinguished, by its cellulose structure, from all the neighbouring genera, except *Biddulphia* and *Amphitetras;* but these differ in their frustules not being oblique, and in having all their ends elongated. Kützing makes it a member of the family *Biddulphieæ*

"The mode of growth in this genus is very curious. In *Diatoma*, as well as in most of the *Diatomeæ*, the plant increases by a division of the frustules; but, in this genus, as also in *Biddulphia* and *Amphitetras*, two new frustules are formed within the old one, and as they enlarge, rupture it, when it falls off. In these, the front portion is at first very narrow, and merely a broad line, but it increases greatly in breadth until the new frustules are fully formed." (Ralfs Ann. Nat. Hist. 1843, p. 270.)

The members of this genus are marine in habit, and seem to prefer the colder northern seas—as the Northern Atlantic, but are absent in the Adriatic, and also in the Mediterranean.

Isthmia *obliquata* = I. *nervosa*, Kütz. Nearly square, with small marginal, hexagonal cells, disposed in parallel decussating lines, with parallel transverse internal marginal septa; ventral portion loosely cellular. Length of frustules 1-90th. On marine Algæ. English Coast.

"The frustules are usually not so wide in proportion to their length, as in I. *enervis*." (Ralfs.)

I. *enervis.*—Marginal cells tetragonal, larger, in transverse parallel lines; no internal septa. Form trepezoid, two to three times broader than long. Length 1-60th. Coasts of England and France. On sea weed (P. 4, f. 183.) As opaque objects, they exhibit great beauty under the microscope; the different portions appearing like reticulations, are shown in relief.

I. (?) *Africana* (Ehr.) — Large flat fragments, resembling the central portions of *Isthmia*, marked by transverse rows of very small cells. Diameter of the largest fragment 1-216th. Oran, Africa.

Genus Licmophora (Kütz.) — Bacilli (frustules) flabelliform; in front, narrowly cuneate; on the other aspect linear, and rounded at apex and base. Stipes thick, rigid.

This genus gives name to the family *Licmophoreæ* of Kützing, which includes, besides, the following genera: viz., *Podosphenia, Rhipidophora*, and *Climacosphenia*. All the forms are marine.

L. *fulgens.* — Frustules geminate, linear, rather wider near the apex, truncate at each end, on the other side perfectly linear; stipes short, thick, dichotomous; arrangement of frustules on it radiating.

Length of frustule 1-132nd to 1·120th. On Algæ, Trieste, Venice, and English and French Coasts (P. 16, f. 20.)

LICMOPHORA *radians* = *Echinella flabellata* (Ehr.)

L. *flabellata* = *Echinella splendida* (Ehr.)

L. *Meneghiniana.* — Frustules slender, very long, linear-cuneate; those terminal on the stipes, radiating; the lateral ones scattered; stipes elongated, sub-divided. Length 1-84th to 1-72nd. Dalmatian Coast, Adriatic Sea.

L. *divisa.*—Frustules long, cuneate, sub-solitary or geminate (not flabellate), acute at the base; stipes short, weak, subdivided. Length 1-240th to 1-180th. On Polysiphonia in the Adriatic (P. 16. f. 16.)

Genus LIOSTEPHANIA.—Orbicular, not concatenate; testa bivalve, its disc not perforated; no internal septa; valves equal (?), smooth both at their centre and border, but with a crown of often strong rays encircling the smooth centre. (This genus is misplaced. Read as in sub-sec. 1.)

L. *Rotula,* with six to fourteen simple rays.

L. *comta,* with 6 to 13 rays, conjoined above by a circlet of puncta.

L. *magnifica,* with twelve rays, a pair of minute rays below, and puncta interposed above.

Genus MICROMEGA.—The generic description of Kützing is substituted for that given by Ehrenberg, as more clearly expressive of the organisms in question. The species are also from Kützing. Compound frond filiform, branched, enclosed by a common external tube, and consisting of rows of navicular bodies. The rows of naviculæ are solitary, and are themselves severally enveloped by smaller, special, secondary tubes, or by curved and very slender fibres.

This genus is nearly allied to *Schizonema,* and one species of the latter, as described by Ehrenberg, is included by Kützing in this.

* *Forms more slender and delicate.*

M. *intricatum.*—Delicate, slightly gelatinous, nebulose, of a pale yellow lustre; finely and irregularly branched; branches spreading, short, and obtuse; rows of naviculæ loose, interwoven with very slender longitudinal fibres; naviculæ oblong, obtuse, truncate, very small. Length 1-1680th to 1-1440th. Length of entire frond half to one inch. Sidmouth, Dorsetshire.

Micromega *parasiticum.* — Slender, tufted, curvate, parasitic, gelatino-cartilaginous, of a pale yellow colour, sometimes brown; very much branched, capillary; series of naviculæ dense; naviculæ in length 1-1380th. Length of frond two inches.

M. *Bombycinum* = *Schizonema Agardhii* (Ehr.)—Of a pale yellow colour, contorted, implicate, curved, much branched, capillary; naviculæ remotely connected, indistinctly defined, and very minute. Heligoland (See P. 4, fig. 208, and P. 17, figs. 43, 44, 45, 46.)

M. *patens.*—Very small, parasitic, floccose-capillary, very fine, gelatinous, branches divergent or patent, obtuse at the extremities; series of naviculæ and the secondary internal tubules distinct, but the naviculæ very small; their length 1-2400th. Length of frond 1-12th.

M. *flagelliferum.* — Small, tufted, parasitic, floccose-capillary, branches erect, divided into flagelliform fibres; rows of naviculæ and internal tubules distinct. Length of naviculæ 1-1920th to 1-1560th. Length of frond 1-12th to 1-6th.

M. *lineatum*—Decumbent, densely tufted, capillary, olive-coloured, elastic, glossy, subramose, branches tapering at the extremity, and widely curved; series of the lanceolate naviculæ very distinct. Length 1-1320th to 1-1200th.

M. *floccosum.*—Minute, almost capillary, branched, rather delicate, gelatinous; rows of the obtuse and truncate naviculæ, and of the secondary inner tubules, quite distinct. Length of naviculæ 1-720th. Length of frond half an inch.

* * *Forms rigid and cartilaginous.*

M. *hyalinum.*—Colourless, hyaline, gelatinous, soft, setaceous at the base, very branched, branches attenuate, capillary and free at the apex; rows of naviculæ few and lax, interwoven with but few fibres; minute naviculæ, oblong-lanceolate, obtuse on the secondary side, and truncate on the other. Length of naviculæ 1-960th to 1-780th; of frond 1 inch. Trieste and Spalato. Adriatic.

M. *tenellum.*—Colourless, hyaline, gelatinous; cartilaginous, setaceous, branched, sub-dichotomous; branches at the extremity very fine and void; rows of the slender naviculæ, and their tubules, distinct. Length of frond 1 inch. Spalato.

MICROMEGA *hyalopus.*—Colourless at the base, hyaline, branches green, narrow, numerous, tapering to the apex, tufted; the lower rows of naviculæ loose, the upper more closely approximate; internal tubules obsolete; naviculæ on secondary side lanceolate; on the other aspect, oblong, truncate. Length of frond half inch.

M. *ramosissimum.*—Setaceous above the base, rigid, di or tri-chotomous, superior branches very numerous, capillary, in a closely set whorl, more or less elongated; naviculæ in close rows, their tubes distinct; their length 1-720th; lanceolate on one side, oblong, linear, and truncate on the other. Length of frond 1 to 2 inches.

M. *setaceum.*—Setaceous, olive-coloured, rigid, sub-dichotomous, lateral and terminal branches short and spiny; naviculæ in close rows, lanceolate, acute on one side; on the other truncate. Length of naviculæ 1-696th to 1-720th. Length of frond 1-12th to 1 inch.

M. *aureum.*—Arborescent, setaceous above the base, rather rigid, ochre-coloured, much branched, branches dense, capillary, pale, slender, and mucous; rows of naviculæ close; tubules distinct; naviculæ on one side lanceolate, on the other oblong and truncate; their length 1-960th. Length of frond 1 to 1½ inch.

M. *corymbosum.*—Arborescent, rather stout at the base, firm, rigid, of a yellowish olive colour; much branched, the branches setaceous, rigid, and disposed in a corymbose manner; the series of naviculæ and tubules distinct, close; the naviculæ elliptic-lanceolate; on one side oblong and truncate. Length 1-960th. Length of frond 1½ inch.

M. *myxacanthum.*—Less stout, gelatinous, cartilaginous, pale brown, branches divergent, attenuate at the base, multifid and digitate at the apex, the gaping incisions acute; naviculæ lanceolate, in fewer and looser rows below, in closer ones above. Length of naviculæ 1-790th to 1-650th.

M. *apiculatum.*—Setaceous, olive-coloured, rigid, branches erect, dilated, and acute at the apex, lanciniated throughout; series of naviculæ close; secondary tubules distinct; naviculæ lanceolate, the other side oblong, truncate. Length 1-650th. Length of frond half-inch.

M. *Medusinum.*—Cartilaginous, gelatinous, hyaline, and brownish, turgid at the base, branches irregular, much thickened at the base,

but broken up into fibrous bundles (penicilli) at the apex; rows of naviculæ lax, overlayed by longitudinal flexuose, and interwoven fibres. Length of frond half-inch.

MICROMEGA *chondroides.*—Small, cartilaginous, olive-coloured; terminal branches aggregate, clavate, obtuse, with scattered spiny hairs; naviculæ membranous, flaccid, minute. Length 1-1380th to 1-1320th. Length of frond one-sixth to one-third inch.

M. *spinescens.*—Particularly spinous, rather dilated; terminal branches acute, spiny; rows and tubules very distinct, close; naviculæ lanceolate; on the other side oblong, truncate. Length 1-960th to 1-720th. Length of frond one-third to half-inch.

M. *albicans.*—Setaceous, white, or olive green; branches and branchlets equal in thickness, fasciculate or verticillate; naviculæ in distant rows, lanceolate. Length 1-1200th to 1-1080th; tubules distinct. Length of frond half-inch.

M. *polyclados.*—Setaceous, dichotomously branched, branches long, slender, rather rigid; naviculæ obsolete (membranous?) flaccid, in distinct tubules; spores elliptic. Length of frond 1 inch.

M. *pallidum.*—Pale rigid, somewhat hard, much branched; branches and branchlets short, divergent, obtuse; naviculæ in lax rows, and in distinct tubules. Length 1-720th to 1-696th (P. 17, f. 39, 40, 41, 42).

M. *corniculatum.*—Stout at the base, rather firm, plane, dichotomous, much branched at the summit, ultimate divisions spinous; naviculæ slender, lanceolate, in distinct tubules. Length 1-600th. Length of frond as much as two inches. Trieste.

Var. (*b.*)—Ultimate divisions penicillate; fibrous.

M. *Blyttii.*—Frond elongate, filiform, sub-divided many times in a dichotomous irregular manner, cylindrical, not attenuate. On the Russian coast. This is a doubtful species.

Genus NAUNEMA (Ehr.) *Monema* (Greville).—Envelope double; the inner one, or lorica, siliceous and navicula-shaped; external one, or mantle, gelatinous and tubular. From the self-division of the lorica and body being perfect, whilst that of the mantle is imperfect, they are developed in separated filiform tubes, often branched, and, as a whole, presenting a conferva-like appearance.

The lorica is incombustible, but the mantle is not. Two openings only are seen, these are central. In some a canal seems to run from one end to the other. Granular contents yellowish-green.

This genus is not recognised by Kützing, who distributes its members chiefly with *Schizonema.*

NAUNEMA *Amphioxys.*—Navicular bodies small, linear-lanceolate, acute, smooth, densely grouped in bundles. Mexico, in fresh water (?). A very doubtful species, says Kützing (P. 15, f. 55, 56, 57).

N. *Americanum.*—Very large, sub-acute, linear, aggregated in branched dense tubules; striated, eighteen striæ in 1-1152nd. Length 1-192nd. Alive in the Hudson, N. America.

N. *simplex (Shizonema,* Ag.)—Lorica oblong, rounded at the ends, and smooth, resembling *N. arbuscula.* Naviculæ (frustules) disposed in a simple series within flexible filiform tubes. Found upon Ceramium hyalinum, and other sea-weed. Length 1-1150th to 1-570th.

N. *Dillwynii* = *Schizonema Ehrenbergii* (Kütz.)—Naviculæ oblong, small, rounded upon the dorsal and ventral surfaces, and densely arranged in many series, within simple branched tubes; always firmly attached. In salt water. Length 1-2300th to 1-1150th.

N. *Hoffmanni.*—Naviculæ small, smooth; numerous and dense within branched tubes. Found in brackish water. Length 1-1150th.

N. *Arbuscula. The tree-like Naunema.*—Naviculæ robust, striated; numerous and dense, within erect fruticose tubes. Length 1-860th.

N. *Balticum.*—Naviculæ long, narrow, striated. Fig. 207 represents a portion of a gelatinous tube, surrounding several. They are numerous and dense within flexible branched tubes, which are tufted. In salt water. Length 1-860th.

Genus RHAPHIDOGLŒA (Kütz.)—Phycoma (thallus), globose, gelatinous, soft; its substance filled by bundles of navicular bodies, disposed in radiating threads.

This belongs to Kützing's great family *Naviculeæ,* and to its subsection *Schizonemeæ.*

All the species are marine.

R. *medusina.*—Small, fasicles lanceolate, acuminate, radiating in irregularly reticulate or branched threads; naviculæ lanceolate. Length 1-600th. Diameter of frond 1-12th.

RHAPHIDOGLŒA *manipulata.*—Globose, fusiform; rays of fasicles reticular, not interrupted; naviculæ linear-lanceolate, obtuse. Length 1-700th to 1-290th.

R. *interrupta.*—Pisiform; fasicles slender, interrupted in a joint-like manner, their divisions tapering; naviculæ linear, truncate, and rather attenuate at each end. Length 1-300th.

R. *micans* = *Naunema micans* (Ehr.)—Subglobose; fasicles large, in irregular obsolete rays, naviculæ linear-lanceolate, subulate, long, and rather acute. Length 1-144th.

Genus SCHIZONEMA.—Envelope double, inner one siliceous, navicula-shaped; the external gelatinous resembling that of *Naunema*, but the tubes are connected together in a bundle-like manner, not branched, though they appear so when spread out. This description is as given by Ehrenberg, but that great observer had, at the date of his work, 1838, given less attention to this genus and to the other compound forms of *Diatoma*, of which it may be taken as the type, than to the other genera of this section. On the other hand, Kützing appears to have more fully studied them, and has added very much to their numbers. Thus he has collected twenty-six species of *Schizonema*, when only one was given by Ehrenberg; and it so happens that this very one is transferred by Kützing to the allied genus *Micromega*. Although, therefore, Kutzing's account of *Schizonema*, as also of *Micromega*, is not perfect, and errors have been detected by naturalists, yet it is the best presented to us at present, and we shall therefore give it concisely. Besides the twenty-six species from Kützing, we are able to add several from that excellent observer, Mr. Thwaites, and one recently described by M. Montagne.

Kützing defines *Schizonema* as a compound frond, filiform, slender, lax; composed of gelatinous branched tubes *(cœloma)*, inclosing longitudinal rows of short navicular bodies. Spores (spermatia) simple, external to the tube, on which they are sessile.

This genus gives name to the sub-section of Naviculæ, the *Schizonemeæ*, which embraces *Frustulia*, *Berkeleya*, *Rhaphidoglœa*, *Homœocladia*, *Schizonema*, *Micromega*, and *Dickieia*, genera all possessing the double lorica of Ehrenberg; in other terms, composed of navicular-shaped corpuscles, imbedded regularly or irregularly in a gelatinous substance. These forms superficially, and to the naked eye, resemble

Conferva and Vaucheria, but the microscope displays their peculiar and characteristic navicular bodies.

The closest affinity between these forms and the ordinary Algæ exists in the case of *Schizonema* with *Hydrurus;* but the round corpuscles of the latter are organic like their enveloping mucus, and not siliceous as are the navicular bodies of the former; a further difference between the two is to be found in that *Schizonema* are all marine, and *Hydrurus* fresh-water habit.

The following are the peculiarities presented by the gelatinous envelope of the *Schizonemeæ.*

In *Frustulia* the investing sheath is gelatinous, and without definite form or outline. In *Schizonema,* and similar genera, the gelatinous substance forms itself into tubules of determinate form and ramification; these tubules containing the naviculæ. In *Micromega,* besides these external tubular ramifications, there are also finer internal tubules, which contain the naviculæ, and the entire substance is firmer, more solid, often cartilaginous, like many species of *Gigartina, Gelidium,* and *Sphærococcus.*

In *Dickieia,* the gelatinous matter is developed in a leaf-like form, as a *Phylloma* or *Thallus,* like as in species of *Ulvaceæ.* In *Encyonema* the navicular bodies are different from those of the other *Schizonemeæ.*

Kützing affirms, that in *Micromega* he has seen the naviculæ metamorphosed into green globular spores, a most interesting fact, if confirmed. In the 'Species Algarum,' thirty-eight species are given.

Schizonema *minutum.*—Parasitic, very short, slender, decumbent, subramose, branches tapering to acute extremities, series few (2 to 3), containing the naviculæ, which are acutely lanceolate, or laterally linear. Length of naviculæ 1-1176th; of the tubes 1-36th to 1-24th. On marine Algæ.

S. *humile.*—Parasitic, very short, cœspitose (tufted), erect, subramose; branches obtuse, hyaline, and naked at the apices; series few (two to four); naviculæ linear-lanceolate, acute, laterally linear, truncate; in length 1-1200th. Length of frond, 1-12th to 1-10th.

S. *tenellum.*—A compact, gelatinous, densely intricate lamina, of a pale green or brown colour; tubes very slender, colourless, hyaline,

mucous, and fragile, sparingly branched; naviculæ truncate, loosely distributed in indefinite lines. In length 1-1380th.

SCHIZONEMA *tenuissimum.*—A compact, mucous, brown, and densely intricate stratum, with crisp, subramose tubes, very slender, hyaline, and fragile; naviculæ very small, obsoletely striated, linear, and truncate. Length 1-1320th.

S. *Illyricum.*—In a mucous stratum, intricate, of a dull and obscure green colour; the tubes (cœlomata) very slender, simple (?), very delicate and hyaline; naviculæ acuminate, lanceolate, in dense rows; when dried, not distinct. Length 1-1680th to 1-1440th. On Conferva, in brackish-water.

S. *tenue.*—In an interwoven dense stratum, of a brownish golden colour; the tubes almost simple, unequal, often contracted, hyaline; naviculæ in indistinct rows, oftentimes without regularity in disposition, oblong, linear, and truncate in form. Length 1-1200th.

S. *lutescens.*—Tufted, undulating, glossy; of a pale reddish colour when dried; cœlomata almost simple, capillary, coloured and naked at the base; hyaline, and covered with naviculæ at the apex; naviculæ oblong, lanceolate, obtuse. In length 1-1200th.

S. *rutilans.*—Tufted, undulating, of a deep, shining, chestnut colour, green at the apex; tubes nearly simple at the base, brown and bare; at the apex hyaline and covered; capillary; naviculæ agglomerate near the apices; oblong, linear, and truncate. In length 1-1200th.

Var. *(a.)* S. *parvulum.*—Densely tufted, of a dull and opaque green colour; naviculæ remote, scattered, without regularity, slender, and linear. Frond 1-6th to 1-4th.

Var. *(b.)* S. *Lubricum.*—Tufted, green, with crystalline tubes; with hyaline and particularly mucous branches at the apex; naviculæ rather larger, wide, and very distinct. Length 1-1080th.

Var. *(c.)* S. *Hoffmanni.*—Tufted; pale green at the base; brownish at the apex; crisp tubes, hyaline (not coloured); naviculæ close, very distinct, oblong, widely truncate, and on the other side lanceolate. In length 1-960th to 1-1080th.

Var. (*d.*) *viride* = S. *balticum* (Ehr.)—Tufted, green; cœlomata, hyaline, colourless; naviculæ slender, linear-lanceolate, obtuse. In length 1-1200th.

SCHIZONEMA *Ehrenbergii* = *Naunema Dillwynii.*—Parasitic, shining, tufted, green, ramose; tubes branched, crystalline, branches obtuse at the apex ; naviculæ (in dried specimens) indistinct, very delicate, obsoletely striated; on one side oblong, truncate; on the other, with rounded ends. Length 1-1320th.

S. *Dillwynii.*—Tufted, wavy, shining; of a beautiful green colour, very much branched; upper branches short, numerous, spreading, and rather acute; tubes crystalline; naviculæ near the base, remotely scattered; above agglomerate; on one aspect, lanceolate, on the other oblong and truncate. In length 1-1000th.

S. *sordidum.*—Small, tufted, parasitic, of a dull greyish-brown colour; tubes imperfectly dichotomous, colourless; their divisions equal; naviculæ oblong, slender, and truncate on one side; on the other, linear-lanceolate, obtuse. Length 1-1440th to 1-1200th. Length of frond 1-6th of an inch.

S. araneosum.—Of a greenish-brown colour, tufted, tubes capillary, branched, colourless; naviculæ in distinct rows, closely aggregate at the upper end of the tubes; on one side exactly lanceolate, acute; on the other, oblong, truncate. In length 1-720th to 1-650th.

S. *floccosum.* — Tufted, intricate, very branched; tubes hyaline, larger, rather acute at the apex; naviculæ distinctly in rows; on one side lanceolate, acute; on the other, oblong, truncate. Length 1-600th. Length of frond 1-2nd to 3-4th of an inch.

S. *crispum.* — Small, crisp (curled); green, branched; tubes dilated, capillary, multifid, and obtuse at the apex; naviculæ densely aggregate, in obsolete series, very small.

S. *plumosum.*—Tufted, wavy, rather curled, green—branched in a pyramidal form; tubes densely crowded at the extremity, dilated and multifid; naviculæ distinct; on one side, oblong-elliptic, with rounded apices; on the other, oblong, truncate, very small. In length 1-1440th. Length of frond 1 inch.

S. *striolatum.*—Tufted, green, crisp, capillary, pyramidally branched; tubes transversely striated, imperfectly hollowed at the base, crowded at the apex, crystalline throughout; naviculæ oblong, with tapering obtuse ends on one side; on the other truncate. Length of frond 1 inch.

S. *capitatum.* — Bright green, setaceous; branches long, slender,

corymbose at the summit, acute; naviculæ in very distinct rows, small, lanceolate on one side; on the other oblong and truncate. In length 1-1200th. Frond as much as 2 inches.

SCHIZONEMA *tricocephalum.*—Of a shining-green colour, very setaceous, rigid, tufted, sparingly branched; inferior branches scattered, simple; terminal, aggregate, subulate, and curved; naviculæ in very close rows, small, broadly oblong and truncate. In length 1-1440th. Frond 1 inch.

S. *Bryopsis.*—Green, setaceous, rigid, branched; upper branches scattered, spreading, obtuse; naviculæ larger, oblong; on one side rounded, on the other truncate. Length 1-2000th to 1-650th. Size of frond 1 inch.

S. *Arbuscula* = *Naunema arbuscula* (Ehr.)—Green, or greenish-yellow, very setaceous, rigid; branches scattered, fasciculate, acute, erect; naviculæ very large, in rows; on one side lanceolate-elliptic, on the other broadly oblong and truncate. Length 1-504th. Breadth 1-2160th. Size of frond 2 inches.

S. *hydruoides.*—Green or brownish, very setaceous, rigid, with long branches and fasciculate; secondary divisions capillary; naviculæ in rows, aggregated, small, but of greater proportional width; apices on one side round, on the other truncate. In length 1-1380th. Size of frond 2 to 3 inches.

S. *Smithii.*—Arborescent, with a rather thick and almost simple stem, but with a very branching apex, the branches being in dense bundles; setaceous at the base, tapering upwards and capillary; naviculæ large, on one side lanceolate and somewhat obtuse; on the other, oblong and truncate. Length 1-600th. Size of frond 2 inches.

S. *helmintosum.*—Thick, much branched; branches and branchlets gradually tapering to acute ends; naviculæ large, intertwined by very delicate fibres; their length three times their width; on one side sub-elliptic, with rounded ends; on the other, ends truncate. Length 1-600th. Size of frond 2 to 3 inches.

S. *Scoparium.*—Thick and branching; branches dilated upwards, cleft at the apex into very numerous capillary bundles, or secondary divisions; naviculæ large, in a mesh-work of very delicate fibres;

oblong on one side with round ends, on the other with truncate ends. Length 1-600th. Length of frond one inch.

SCHIZONEMA *Grevillii.*—Tufted, slender, capillary, branched, brownish-green; tubes dichotomous, transversely striated at the base; naviculæ longitudinally and obliquely disposed, very large, with longitudinal lines; oblong-truncate on one side; on the other, lanceolate, acute; in length 1-576th. Length of frond one and a half inch.

S. *mucosum.*—Particularly mucous and soft; tubes (cœlomata) obsolete, contiguous, implicate; naviculæ very large, in rows; on one side, lanceolate-oblong, and obtuse at the ends; on the other, oblong and broadly truncate; in length 1-420th to 1-360th.

S. *Agardhii* (Ehr.) = *Micromega Bombycinum* (Kütz.)—Lorica (naviculæ) very narrow, acute at both ends, placed in single series; tubes filiform, dilated in the position of the enclosed naviculæ (See fig. 208 which represents a bundle of these tubes magnified 300 diameters.) Length of naviculæ 1-720th. North Sea.

S. *investiens* (Montagne.)—Parasitic, fasciculate, minute, glossy, opaque brown; filament dilated at the base, and diffusely ramose; branches anastomosing; naviculæ in one or two rows (uni or biserial), rather large; each with two nuclei, and cymbiform. The two nuclei of the naviculæ are in shape of two isosceles triangles opposed base to base. The naviculæ are mostly in single series, very rarely in double. Notes on the Cryptogamia of Guiana in Ann. des. Sciences. Nat. vol. 14, 1850, p. 308.

S. *eximium.* (Thwaites.)—Thallus simple or sparingly branched, rugose; naviculæ sigmoid, smooth, (Ann. Nat. Hist. 1848, p. 169.)

The sigmoid frustules of this beautiful fresh-water species at once distinguish it from any other described *Schizonema.* The delicate gelatinous sheaths are simple, or very sparingly branched and minutely rugulose, especially near the base; they contain from one to four rows of the large, smooth, sigmoid frustules. Found in the filaments of *Vaucheria,* stems of grasses, &c. In a stream near Bristol.

S. *subchærens* (Thwaites.)—The tubules (sheaths) cohering in an amorphous mass, very numerous, branched; containing oftentimes many single rows of naviculæ; naviculæ broadly truncate, suddenly

narrowing near the apices, and striated. Closely allied to S. (?) *mucosum* (Kütz.), but differs from it in having the frustules striated; and towards the apices suddenly narrowed. Tufts of the plant from a quarter to half an inch or more high; filaments very mucous and tenacious, and each containing from one to several single rows of frustules, which are continued without interruption into the branches. The sporangia of this species are produced by the conjugation of a pair of frustules, outside the filaments; but sporangial frustules are frequently found in a filament intermixed with ordinary frustules, from which they differ only in size. This species appears to belong to Agardh's genus *Micromega*, but it is difficult to see the advantage of creating a new genus from characters derived from the mucous sheath only, and which characters really may be present in some species, without being clearly evident. The so-called *spermatia* of *Micromega*, now that the true sporangia have been discovered, require further examination; a somewhat similar appearance to what is figured by Kützing, is evidently due to minute *Zoopytes* in an immature state.

Schizonema *vulgare* (Thwaites.) — Naviculæ smooth, lanceolate, suddenly contracted near the apices. Habitat in fresh-water.

Var. (*a.*) *rivulorum.*—Tubules distinctly ramose; naviculæ subacute.

Var. (*b.*) *lacustre.*—Tubules mucous, simple (or sparingly branched;) naviculæ more broadly truncate than in preceding variety. *Monema lacustre* (Agardh.)

Var. (*c.*) *effusum.*—Tubules distinct, diffused through a gelatinous stratum; naviculæ as in var. (*a.*)

Although this is perhaps the commonest species of all the *Schizonemata*, since it occurs, during the spring, in almost every ditch and running stream, yet it does not appear to have hitherto been described, unless the *Monema lacustre* (Ag.) should prove to be one of its forms. This species is most abundant in shallow streams, covering stones, &c., with a dark brown gelatinous coating, but in which a linear arrangement of the frustules may frequently be detected. When the plant occurs in deeper water, the ordinary *Schizonema* filaments make their appearance, which are much branched when growing in rapid streams, but in still water are simple or nearly so. In the last named form of the species, perhaps the *Monema lacustre*, there is also

a slight difference in the form of the frustules, which are rather shorter compared with their width, and are more truncated at their extremities.

SCHIZONEMA *neglectum* (Thwaites.)—Tubules ramose, mucous; naviculæ lanceolate, delicately striated. In brackish water near Bristol. The filaments of this species are branched, especially towards the base, and easily escape detection, owing to particles of sand and other substances adhering to their tenacious surface, and being with difficulty removed from it. The frustules are very like those of S. *floccosum*, (Kütz.) but the latter are not striated, and are included in a gelatinous sheath of much greater thickness.

At the conclusion of his description of the *Schizonemeæ*, Kützing has appended the names of fifteen species, collected from various authors which are doubtful, members of the genus; for these we must refer to that writer's monograph.

Genus SYNCYCLIA (Ehr.)—Envelope double; inner one, or lorica, siliceous, navicular; external envelope amorphous, gelatinous. The naviculæ develope in clusters by self-fission, within the gelatinous investment. Ehrenberg states, that there are two openings near the middle, on one side, but they are indistinct.

The following characters are from Kützing.

"Individuals cymbelliform; transversely connate, in curved circular bands (bundles), imbedded in a soft amorphous and gelatinous substance."

In Kützing's arrangement, *Syncyclia* is one of the family *Cymbelleæ*.

S. *quaternaria*.—Corpuscles in pairs, or in fours, smooth, enveloped in a hyaline jelly, contents of a golden or reddish-brown colour. Length 1·864th. The frustules have the form of *Cocconema cistula*, but are destitute of striæ and pedicles.

S. *salpa*.—Lorica semi-ovate, mostly connected in sixes within the gelatinous substance, and so that on a transverse or end view they appear like a group of corpuscles in the form of a ring. Colouring matter green. Length 1-2300th. to 1-570th.; group 206, showing to the right a single frustule, several side views; and below, an end view of a ring-like cluster.

This form occurs as a mucous film upon sea-weed.

Appended sub-section LITHOTHECIA.

This term was contrived by Ehrenberg, when he described the genus *Mesocena*. The beings constituting this sub-section of *Naviculacea* are far removed by general characters from the rest of the family, and seem to form a transition group between *Naviculacea* and *Phytolitharia*, which are illustrated by the siliceous skeletons of sponges.

Genus ACTINISCUS. — Individuals solid, with rays; their figure recalling that of a star.

It differs from *Dictyocha* and *Mesocena*, in having a solid centre or body, from which rays, varying in number and form, proceed.

Actiniscus, together with *Mesocena* and *Dictyocha*, form the family *Actinisceæ* of Kützing; who observes, that these beings were first made known by Ehrenberg, in 1838 and 1840; and that, by their peculiar form, they have little or no resemblance to other *Diatomeæ*. They are all marine; abundant in a fossil state; and their shells have numerous foramina piercing them.

A. *Stella.*—Characters unknown.

A. *Discus.*—Disciform; centre smooth; eight marginal rays, not exserted. Diameter 1-2304th. Oran, in Africa.

A. *quinarius.* — Stellate, with five exserted rays. Diameter 1-3120th. Ægina.

A. *Rota.*—Discoid; centre smooth, with ten exserted (projecting) rays from its margin. Diameter 1-1920th. Oran.

A. *Tetrasterias.*—Stellate, with four exserted rays. Diameter 1-1008th. Richmond, Virginia. This may belong perhaps to *Phytolitharia.*

A. (?) *Lancearius.*—Stellate, with eight free (exserted) lanceolate rays standing out from the margin, and some central shorter ones on one side. Diameter 1-240th.

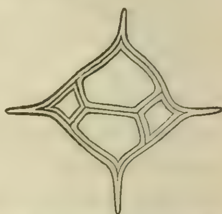
A. *Pentasterias.*—Stellate, with five siliceous rays; centre solid, concave. Diameter 1-1150th. Alive in Norway, and fossil in Greek marl.

A. *Sirius.*—Stellate, with six acute rays expanded (alate) at the base, centre solid. Diameter 1-1150th. Alive, Christiana, Norway.

Genus DICTYOCHA.—Individuals reticulate, spinous, free, solitary. (Kütz.) Characters by Ehrenberg, unknown. Marine.

Concerning these peculiar, yet distinct organisms, almost nothing is known, save their external configuration.

DICTYOCHA *aculeata.*—Cells in the form of a ring, each cell spiny on its inner aspect. External spines long, but unequal in length, and radiating from the circumference. Fossil in the chalk marl of Oran, Caltanisetta, Zante, and Greece; alive in the waters of the Cattegat, near Tjörn. Diameter of fossil forms 1-2304th to 1-1150th; of living, 1-1440th to 1-1150th, without reckoning the horns.



D. *Fibula.* — Form concave, rhomboid or square, with four spiny angles externally, and four interspaces. Fossil in chalk marl, Oran, Caltanisetta, &c. Alive in sea-water near Christiana. Locomotion not observed. Diameter 1-1150th to 1-560th.

D. *Speculum.*—In form of a ring, spines six, long, but unequal in size, radiating from the circumference, cells not spiny within, six open spaces surround a central one. Fossil in chalk marl of Caltanisetta, Oran, and Greece. Alive in the Baltic. Contains, when living, green granules, and locomotion is perceptible after long observation. Diameter 1-860th (P. 15, fig. 62 a front view; fig. 63 a side view (living.)

D. *Crux.*—Cells five, combined in a quadrate form around a central foramen; angles spinous. Diameter 1-624th. Fossil in chalk marl of Caltanisetta, Sicily.

D. *heptacanthus.*—Cells thirteen, in an heptagonal form; seven of the cells marginal; each of the seven angles furnished with radiating spines. Diameter 1-552nd. Fossil in Greek marl.

D. *Navicula.*—Cells eight, figure oblong, obtuse, cylindrical, reticular, with a median septum like a Navicula. Fossil in chalk marl.

D. *polyactis.*—Unarmed, with nine rays, ten marginal cells, and one central, arranged in a reticulate stellate form. In chalk marl.

D. (?) *splendens.*—Oblong, tabular, with dentate apertures (cells) thirteen in number. If it be calcareous, it is similar to *Coniopelta.*

D. *trifenestra.*—Quadrilateral, with elongated aculeate angles, and three internal dentate cells. St. Domingo.

Dictyocha *Binoculus.*—Habit of D. *aculeata,* but with a double central cell. Diameter 1-444th. Ægina, fossil.

D. *elegans.*—Pentagonal, not dentate; angles acute but unarmed; perforated by numerous small cells, and seven central large ones, of which one occupies the centre. Diameter 1-912th. Fossil, Caltanisetta, Sicily.

D. *bipartita.*—Habit of D. *Crux,* but with the central cell bipartite. Diameter 1-504th. Oran, in Africa.

D. *Monodon.*—Habit of D. *Fibula,* with four spines (aculei), but each cell remarkable by a single tooth (denticulus.) Diameter 1-576th Richmond, in Virginia. Ehrenberg described, subsequently, a species under this same name, as being very turgid and hemispherical, with an erect central denticle, peculiar to it; hence he thinks it may constitute the type of a new species. This species, or variety, was found in African Guano.

D. *Haliomma.*—Habit of D. *speculum,* with six spines, and ten irregular cells, of which three are median, and seven marginal. Diameter. 1-840th. Oran.

D. *Hexathyra.*—Habit of D. *Speculum,* with six spines, of which five are marginal, and enclose the remaining one in their midst. Diameter 1-864th. Caltanisetta, Sicily. Fossil.

D. *mesophthalma.*—Habit of D. *Crux,* and of D. *Staurodon,* but with two denticles, one superior, the other inferior, on each marginal cell. Diameter 1-372nd. Caltanisetta. Fossil.

D. *Ornamentum.*—Presents seven spinous rays, each of the seven marginal cells furnished with a denticle; one median cell. Diameter 1-444th. Fossil at Caltanisetta. Allied to D. *septenaria.*

D. *Pons.*—Annular, oblong, divided into two cells by a single median arch; with four external spines. Diameter 1-504th. Oran.

D. *Septenaria.*—Habit of D. *Speculum,* but with seven spines, and seven marginal cells, round a single central, unarmed one; it thus approaches D. *Ornamentum,* furnished with teeth. Diameter 1-864th. Oran.

D. *staurodon.*—Habit of D. *Crux* and of D. *mesophthalma,* but having each marginal cell provided with a denticle. Diameter 1-576th. Richmond, Virginia.

D. *Superstructa.*—Quadrangular, with spinous angles, and con-

sisting of nine cells, of which four are exterior (marginal), and surrounding other four, having the remaining one in the centre. Diameter 1-600th. Caltanisetta. Fossil.

DICTYOCHA *triacantha.*—Regularly triangular, with spinous angles; marginal cells three, unarmed on their inner border. Diameter 1-864th. Maryland.

D. *tripyla.*—Unequal, with three unarmed cells prolonged as rays to the middle; four irregular marginal, cells with spines. Diameter 1-492nd. Oran.

D. *ubera.*—Hexangular; seven marginal cells, and six spines; the two central cells unarmed. Diameter 1-600th. Maryland.

Ehrenberg appends the following remark to the description of the sixteen immediately preceding species, "I have studied to distinguish the forms of this genus, but have not yet been able to determine species and varieties."

D. *hemispherica.*—Hemispherical but hexagonal in outline, with six lateral spines; six opposite marginal cells with spines, and six internal cells surrounding a central one; the lower aperture half closed by six marginal teeth. Diameter 1-744th. Bermuda.

D. *Ponticulus.*—Lanceolate-oblong, divided by a simple transverse median arch into two cells; margin unarmed. Diameter 1-432nd. Bermuda.

D. *Quadratum.*—Quadrate or subquadrate, oblong; divided into two cells by a simple median arch; a single spine on each side. Diameter 1-480th. Bermuda. The two preceding forms were first observed and figured by Dr. Bailey of New York.

D. *biternaria.*—Habit of D. *aculeata,* with short spines and six marginal cells, of which three are larger and adjoin the three others; consequently, not alternating; no median cell. Diameter, without spines, 1-432nd. Antarctic Ocean.

D. *octonaria.*—Habit of D. *ornamentum* of Sicily, with eight spines, one larger than the rest; marginal cells irregular, fewer in number at that part where the spines are increased, and with a very large central cell. Diameter, exclusive of spines, 1-1152nd. If a monstrous variety of D. *ornamentum*?

D. *abnormis.*—Quadrangular, with spinous angles; five internal,

but no central cell. Diameter 1-1080th. In African Guano, considered as fossil.

There is, too, a variety with five spines, of which two are smaller; and have the inner margin of the cells dentate. Diameter 1-648th. This may be another species.

DICTYOCHA *diommata.* — Hexangular, with spinous angles; eight internal cells, and two central, unarmed. Diameter 1-660th. Fossil in Virginia.

D. *Stauracanthus.*—Eight-sided; spinous angles alternately longer; five inner cells, one median and four marginal, each armed with a tooth. Diameter 1-648th. Fossil. Virginia and Connecticut.

D. *triommata.*—Hexangular, with spinous angles; nine inner unarmed cells; three median. Diameter 1-864th. Virginia. This species, and also D. *diommata*, resemble, in their turgid habit, D. *hemispherica*, of which they may be but varieties.]

D. *gracilis* (Kütz.)—Slender, small, with elongated slender spines, cells internally unarmed. Resembles in the main D. *Speculum.*

Genus MESOCENA.—Lorica simple, siliceous, univalve, occurring as a ring, perfectly circular, or angular, and often armed with projecting spines (teeth.)

This genus resembles *Dictyocha*, but is destitute of its central organization. Ehrenberg remarks that *Mesocena* would be referrable to the family *Desmidiacea*, had not that family a membranous lorica, whilst it possesses a siliceous one.

This genus, in Kützing's arrangement, belongs to the family *Actinisceæ.*

M. *Circulus.*—A single circular cell with a dentated margin. Diameter 1-576th. Fossil in Greek marl.

M. *elliptica.*—A single elliptical cell obscurely quadrangular, with four spines disposed in a quadrate manner on its margin. Diameter 1-624th to 1-456th. Fossil in marl from the island of Zante.

M. *triangula* —Triangular, with rough sides, and mucronate apices. Fossil in chalk marl.

M. *Diodon.*—In the form of a smooth elliptic ring, armed at each end with a small tooth. Diameter 1-396th. Maryland.

M. *Spongiolithis.* — An elliptic ring with four slight alternating swellings. Diameter 1-492nd.

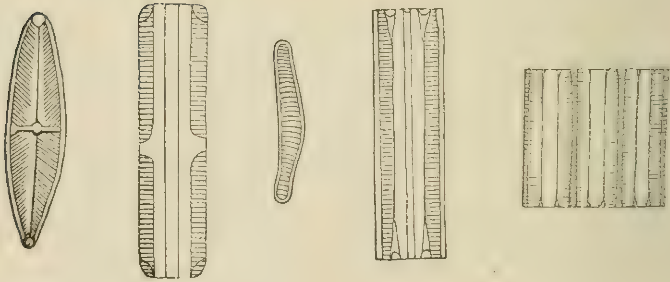
It exactly resembles a perfectly annular *Spongiolithis brachiata*, and is a doubtful member of the genus *Mesocena*. The *Spongiolithis* belongs to the class *Phytolitharia*.

Mesocena *binonaria*.—A slender ring with nine angles, each armed with a denticle, and these alternating with the same number of denticles on the inside. Diameter 1-768th. Fossil in Peruvian guano.

M. *bioctonaria*.—A slender ring with eight exterior spines and angles, and as many alternating internal denticles. Diameter 1-768th. Fossil in Peruvian guano.

M. *heptagona*.—The ring with seven external teeth. Peru (P. 15, f. 71.)

M. *octogona*.—The ring with eight external teeth or spines. Peru.



FAMILY.—CYCLIDINA.

The Infusoria of this small family are polygastric, devoid of true alimentary canal, and have but one opening. They have no lorica; their bodies are furnished with cilia or bristles, which perform the function of locomotion, and the various groupings and relations of these, afford characters for the discrimination of the genera; a distinct proboscis has been seen. The system of nutrition has been distinctly observed in two species of *Cyclidium;* ova have been seen only in *Pantotrichum Enchelys.* No visual organs have been observed.

The genera are distributed as follows:—

Body furnished with cilia	Body compressed—cilia arranged in a single circle	Cyclidium.
	Body round—cilia scattered all over	Pantotrichum.
Body furnished with bristles	....	Chaetomonas.

This family *Cyclidina* has no corresponding one in the system of Dujardin. Some of its members are represented in the family of the *Encheliens* of that author, among the examples of the genera *Acomia* and *Enchelys.*

On the other hand, the genus *Cyclidium* (Duj.), is included in his family *Monadina* (page 133), and, consequently, is made to include beings furnished with a filament (proboscis), but destitute of mouth and cilia—characters not at all analogous to those given by Ehrenberg to his genus of this name

Genus CYCLIDIUM.—*The disc Animalcules* have a compressed body, provided with cilia, placed in a simple circular row. In C. *glaucoma,* the polygastric apparatus (stomach-cells) is distinct. The mouth is a roundish opening, situated upon the under surface of the body, either close at the anterior extremity, or towards the centre. The organs of locomotion are neither proboscides nor oral cilia, but consist, as in *Kerona* and *Stylonychia,* of a number of cilia-like feet, situated on the margin of the abdomen. Lately it has been thought that longitudinal lines, produced by rows of very delicate cilia, were present; if so, and an anal opening be discovered, C. *glaucoma* would

rank among the *Oxytrichina.* Transverse self-division is very common, but longitudinal has not yet been observed. The female sexual apparatus is unknown, but a large round gland is seen in C. *glaucoma* and C. *lentiforme.*

Cyclidium *glaucoma* (M.)—Body oblong-elliptic, abdomen fringed with cilia, and delicate longitudinal striæ are observed upon the back. In swimming, they resemble *Gyrinus*, or *Notonecta*, a well-known little black water beetle (see *Microscopic Cabinet, plate* 4), which swims in flocks, glancing like silver upon the surface of the water of shady ditches. Sometimes the movement is very quick; at other times the animalcules remain for a while stationary, and then presently spring with a curvetting motion to another spot. Formerly this species was confounded with *Gyrinus scintillans;* but the latter is much larger. (P. 4, f. 209 is a side view, showing the cilia; fig. 211 a dorsal view; and fig. 210 a specimen undergoing transverse self-division.) They are represented as fed with indigo. Abundant in vegetable infusions in the spring. Length 1-2880th to 1-1150th.

C. *margaritaceum.*—Body orbicular, elliptical; the posterior end slightly excised; the dorsal surface has distinct longitudinal lines, the cilia not distinct. Length 1-1500th to 1-1000th.

C. (?) *planum.*—Body oblong-elliptic, smooth; cilia but little marked. Size 1-2640th.

C. (?) *lentiforme* is smaller than the preceding, and has no distinct striæ or cilia. Size 1-3180th.

Genus Pantotrichum. *The muff Animalcules.* — Body turgid, covered with moveable cilia. In P. *Enchelys* stomach-cells are distinctly visible. Ova are not satisfactorily seen, though the green colour of P. *volvox*, and the yellow-coloured matter of the other species, probably indicate their presence. Ehrenberg says, "the absence of a double opening is not yet proved, nor, on the other hand, is its existence."

P. *Enchelys.*—Body cylindrical, oblong, rounded at both ends. It is of a pale yellow colour, but hyaline at the two extremities, and turbid at the centre. Fig. 212 is a cluster of animalcules; those to the left, are more highly magnified than the others. In swimming they revolve and glide along in the direction of the longer axis of the body. Found in infusions of raw flesh. Length 1-1150th.

PANTOTRICHUM *volvox (Leucophrya viridis*, M.)—Body ovate, spherical, of a green colour. Found in brackish water. Size 1-860th.

P. *Lagenula.*—Body ovate, equally rounded at the two ends, and having the anterior ciliated portion produced in the form of a neck or beak. Found amongst Conferva. Size 1-1080th to 1-570th.

Genus CHAETOMONAS. *The bristle Monad Animalcules.*—Oral cilia vibratory; motion slow, and leaping by means of the bristles on the body, which are not vibratile. Very little is known of their organization. They are parasites, living on the dead bodies of other Infusoria, and in infusions of flesh or of animal matter. Whether the delicate vibration seen at the mouth is produced by a proboscis or by cilia, is uncertain. In C. *constricta,* transverse self-division is thought to have been seen.

C. *globulus* is almost spherical, of an ash colour, and possesses setæ, or bristles. This animalcule has often the figure of *Monas guttula,* though the latter is smaller; sometimes two cluster together. Found in bad smelling infusions of animal matter along with *Pantotrichum Enchelys, Monas termo,* &c.; also in the dead bodies of *Closterium acerosum,* as shown at fig. 113, which represents part of the latter, with several animalcules around it. Size 1-2880th.

C. *constricta* is transparent, oblong, slightly constricted at the middle, and having two setæ, or bristles. Found in dead *Hydatina senta.* Size 1-5760th.

FAMILY.—PERIDINAEA.

Comprehends vibrating animalcules, distinctly or apparently polygastric, devoid of an alimentary canal, covered with a shell, or lorica, upon which, or upon the body, are cilia or setæ: these are often arranged in the form of a girdle or crown—hence the name. The lorica has only one opening. In three out of the four genera an organ of locomotion is present, in the form of a delicate proboscis, independent of the wreath of cilia around the middle of the body, or scattered cilia or bristles. In only *Peridinium pulvisculus* and P. *cinctum* have artificial means succeeded in demonstrating the nutritive appa-

ratus; for it is mostly covered by clusters of ova. In *Peridinium tripos* the seminal glands are evident. In four species, a system of sensation is indicated by the presence of a red-coloured visual point.

The genera are disposed as follows:—

Lorica having stiff bristles or short spines—no transverse furrowed zone	no eye	Chaetotyphla.
	eye present	Chaetoglena.
Lorica smooth or rough—a ciliated transverse zone present	no eye	Peridinium.
	eye present	Glenodinium.

Some of the species have been found only in a fossil state; these are obtained from the chalk formations in flint, but are not figured in *Die Infusionsthierchen.*

Dujardin constitutes a family *Peridiniens*, agreeing in the main with that of Ehrenberg. He thus narrates its characters: "Animals without known internal organs; enveloped in a regular, resistant, membranous lorica, which sends off a long flagelliform filament, and, in addition, has one or more furrows beset with vibratile cilia.

"The lorica would appear to have no opening, for foreign bodies and colouring matter are not seen to enter it. Several have their lorica prolonged into horn-like processes; and some exhibit a coloured point (eye speck.) They are distinguished from *Thecamonadina*, by the ciliated furrow or furrows.

"Of the two first of Ehrenberg's genera, Dujardin observes, these being without the furrow and vibratile cilia, and having only a filament as a locomotive organ, are evidently akin to, and not to be separated from the *Thecamonadina*, unless spines or asperities of the lorica are to be taken for cilia. Again the so-called eye-speck is not a sufficient generic distinction between *Peridinium* and *Glenodinium;* the former genus, moreover, should only include spherical animalcules, whilst those concave on one side, and exhibiting horns, will rightly form a distinct genus—*Ceratium.*"

Genus Chaetotyphla. *The bur Animalcules.*—Lorica siliceous, hispid or spinous, destitute of a transverse furrow or zone, and visual organ. The surface is covered with little spines and bristles, which appear stronger at the posterior portion of the body. By pressing the animalcule between the plates of an aquatic live-box, the lorica bursts, and sets the little creature in the interior of it at liberty.

In swimming it revolves upon the longitudinal axis; this motion is probably produced by a delicate filiform proboscis, or by cilia at its mouth, but though evident, the organs producing it have not been seen. Of the nutritive, sensitive systems, &c., nothing positive is known. One species has been discovered in flint, which so closely resembles *Xanthidium*, that it is often mistaken for it.

CHAETOTYPHLA *armata*.—Is of a brown colour, ellipsoidal form, with rounded ends; the posterior is covered with short spines, and has a circlet of black spots, as shewn in the end view, fig. 215. The anterior cilia or fine bristles, are sometimes very indistinct; fig. 214 is a variety in which they are strongly marked. Found in clear water, amongst Conferva. Length 1-620th.

C. *aspera*.—Is brown; body oblong, rounded at both ends, and rough, with short bristles; the little spines are scattered without order at the posterior end. Found with the preceding. Length 1-570th.

C. (?) *pyritae*.—Body oblong cylindrical, rounded at both ends, and provided with delicate elongated bristles, but destitute of spines. Found fossil, in flint, near Delitzsch. Size 1-1150th.

Genus CHAETOGLENA.—*The bristled and eyed Animalcules* have a siliceous lorica, striped or covered with spines or stiff hairs, and an eye; they are destitute of a transverse zone or furrow. The organ of locomotion is a simple flabelliform proboscis. The interior contains scattered transparent vesicles, probably stomach-cells. The ova cluster is a brownish-green granular mass; a large bright spot or spermatic gland is also visible. Self-division has not been observed.

C. *volvocina*.—Body ovate, with brownish-green oval and a red eye; between the lorica aud the soft body a beautiful red ring is visible in the live specimens. (See fig. 216, 217, and 218.) Found amongst Conferva, at Hampstead and Hackney. Length 1-1150th.

C. *caudata*.—Body hispid, ovate, with a short tail; ovules green; ocellus (eye) clear red; oral margin urceolate and dentate. Size 1-864th. Berlin.

Genus PERIDINIUM. *The wreath Animalcules*.—Lorica membranous, with a transverse ciliated zone; no eye. The locomotive organs are a filiform proboscis, and the zone or wreath of cilia. In P. *pulvisculus*

and P. *cinctum* the digestive apparatus can be demonstrated, by employing indigo and carmine as food; but in P. *acuminatum*, P. *fulvum*, and P. *cornutum*, it is visible without having recourse to artificial means. The oral aperture is found in a hollow near the centre, as in *Bursaria*. The ova cluster is generally of a brown or yellowish-brown colour, though sometimes green, or even almost colourless. In P. *tripos*, and P. *fusus* an oval seminal gland is visible. Self-division is longitudinal in P. *pulvisculus* and P. *fuscum;* and, according to some observers, transverse in P. *fusus* and P. *tripos*.

(*a*). *Wreath Animalcules without horns*.—Peridinium.

Peridinium *cinctum* (*Vorticella cincta*, M.)—Is nearly globular, or slightly three-lobed and smooth, with a zone of cilia; it is not luminous at night. It swims slowly, with a vacillating and rolling motion. Found amongst Conferva. Size 1-570th.

P. *pulvisculus*.—Small, of a brown colour, and not luminous at night; lorica almost spherical, or slightly three-lobed; a delicate proboscis may be observed, as well as numerous stomach-cells, by feeding it on indigo. Found with *Chlamidomonas pulvisculus*. Length 1-2300th. to 1-1150th.

P. *fuscum*.—Is not luminous at night; the lorica is oval, slightly compressed and pointed anteriorly. Length 1-430th. to 1-280th.

(*b*). *Wreath Animalcules with horns*.—Ceratium.

P. (?) *pyrophorum*.—Lorica ovate, spherical, with two little points at its anterior extremity. It is very delicately urceolate and granular. Found fossil in the flints of the chalk formation at Berlin. Size 1-570th. to 1-480th.

P. (?) *Delitiense*. — Lorica ovate, spherical; with a little stiff point near the middle laterally. Fossil in the flints of Delitzsch. Size 1-430th. to 1-280th.

P. *acuminatum*.—Colour brownish-yellow; lorica ovate, spherical, slightly three-lobed, and having a little process at the posterior end. "I observed this species," says Ehrenberg, "in phosphorescent sea-water from Kiel, and it is very probable that the light proceeded from this animalcule. It is the smallest phosphorescent sea animalcule that is known. Length 1-600th. to 1-570th.

P. *cornutum* (*Bursaria hirudinella*, M. *Ceratium hirudinella*,

Duj.)—Colour greenish; it is not luminous; its rhomboidal rough lorica has one, two, or three straight horn-like processes in front, and a single one (often curved) posteriorly. Length 1-280th. to 1-140th.

Peridinium *tripos* (*Cercaria tripos*, M. *Ceratium tripos*, Duj.)—Colour yellow; very brilliant in the night (phosphorescent). Lorica urceolate, broadly concave, smooth, and three-horned; the two frontal horns very long and recurved, the third, or posterior one straight. Ehrenberg says, "The power of this creature to evolve light is placed beyond all doubt, as I took up nine phosphorescent drops, one after the other, from the water, and I saw nothing else in each than a single animalcule of this species." It is rigid, and swims with a vacillating rolling motion upon the longitudinal axis. The length of the horns is not constant, sometimes being scarcely so long as the body; at other times much longer. Figs. 219 and 220 represent an under and side view. Found in the sea, near Copenhagen and Kiel. Length 1-140th.; without the horns, 1-430th.

P. *Michaelis.*—Was discovered by Dr. Michaelis; it is of a yellow colour, and intensely phosphorescent. The lorica is ovate, and smooth, with three short, straight horns, as shewn in fig. 221. A proboscis is not visible. Found in phosphorescent sea-water. Length 1-570th.

P. *fusus.* *Ceratium fusus* (Duj.)—Is of a yellow colour; intensely phosphorescent, and brilliant at night. Lorica ovate, oblong, and smooth. The two horns are straight and opposed, giving the creature the form of a spindle, as shewn at figs. 222 and 223; in the latter the proboscis is in the usual vibrating state, Ehrenberg states that he has seen the cilia of the furrowed zone, and the single proboscis when at rest; also an opening or mouth in the lorica, near the insertion of the proboscis. Length, with horns, 1-120th. to 1-90th.

P. *furca.*—Is of a yellow colour, and very phosphorescent; lorica urceolate with three horns; two in front short, and in the form of a fork; the posterior longer. Found in phosphorescent water, at Kiel. Length 1-120th.

P. *divergens.* — Yellow; lorica cordate-ovate, smooth; with two divergent frontal acute spines, dentate at the base; posterior

portion attenuated, looking as if shortly horned. Diameter 1-576th. Found in the Baltic.

Peridnium *macroceros.*—Yellow; habit of P. *tripos*, but more slender, and with longer horns, which are four times the length of the body. Length 1-216th. In the Baltic Sea.

P. *monas.*—Very small, oblong, obtuse, without horns, remarkably social. Diameter 1-1728th. In the Baltic.

P. *Tridens.*—Yellow, with the habit of P. *flavum*, P. *divergens*, and of P. *Michaelis;* surface granular, with three acute frontal horns; and its posterior portion attenuate. Size 1-576th. In the Baltic.

Genus Glenodinium. *The wreath Animalcules, with eyes.*—Peridinæa with mobile cilia, placed in a transverse furrow, or zone, and provided with an eye. The organization is much the same, in other respects, as in the preceding genus. In G. *cinctum* only is a filiform proboscis seen; this emanates from the middle, and, like the wreath of cilia vibrates. This organ, though hitherto unobserved, is probably present in the other species. The lorica is combustible. The stomach-cells, and minutely-granulated ova are visible in all the species, but the former are very distinct in G. *apiculatum.* The red eye is in the form of an elongated or horse-shoe shaped spot, and forms an essential character of the genus. Longitudinal self-division has been observed only in G. *cinctum.*

G. *cinctum* = *Peridinium oculatum* (Duj.)—Lorica oval, or nearly spherical and smooth; eye large, semi-lunar, and transverse. Found in fresh water, amongst Oscillatoria. Size 1-570th.

G. *tabulatum.*—Is oval, of a yellowish-green colour; lorica granular and reticulate with elevated lines, but not spinous; truncate and denticulate posteriorly, and bidentate anteriorly; eye oblong. Size 1-570th. to 1-430th.

G. *apiculatum.*—Is oval, of a yellowish green colour; lorica smooth, but with hispid furrows on the margin, as shewn in figs. 224, 225, and 226. The eye is oblong, and extremities obtuse. Found amongst Conferva, where Chara grows. Size 1-570th. to 1-430th.

Family.—VORTICELLINA.

These polygastric animalcules are provided with an alimentary canal, the extremities of which are distinct, though they approximate, in consequence of its curvature (anopisthia.) They have no lorica; when free, they are solitary, but when attached to a pedicle they are social, often assuming elegant ramose forms, like little trees, an animalcule surmounting and terminating each branch or pedicle. These arborescent clusters are produced by imperfect self-division, (see Plates 5 and 22.)

The animal organization of this family is very distinct, with the exception of vessels and nerves. All the species possess numerous cilia; those of *Stentor* are covered with them; others have them at the mouth, where they are mostly disposed in the form of a wreath; and by their vibratile action locomotion is effected. In some genera, as in *Vorticella*, *Carchesium*, and *Opercularia*, longitudinal and transverse muscles are seen. The polygastric nutritive apparatus may be observed in all the genera, by feeding them upon artificial colouring food. The course of the alimentary canal has been observed in all the genera, except *Trichodina* and *Urocentrum;* the mouth and discharging opening, both lying in the same lateral cavity, have also been demonstrated in all. The sexual system is hermaphrodite, and self-division is known in all; in *Zoothamnium* it is rare. In four genera self-division is imperfect; hence they form beautiful little tree-like clusters. Another mode of propagation is observable, namely, the growth of gemmæ on the side of the animalcules, or of their pedicles. Although a system of sensation is not indicated by the presence of eyes, we may presume its existence by their great irritability when approached.

Some systematists consider that this family affords a connecting link between the classes *Polygastrica* and *Rotatoria.*

This account of the organization of *Vorticellina*, chiefly from Ehrenberg, must, according to later, and most pains taking investigations of other naturalists, be much modified. The result of those

investigations is attached to the account of each genus to which they refer.

The genera are distributed as follows :—

Body without stalk	Tail absent......	Body covered with cilia		Stentor.
		Body smooth, cilia anterior		Trichodina.
	Tail present			Urocentrum.
Body periodically stalked—often branched like a tree	form of stalked bodies similar	Stalk flexible, deflection spiral	Simple	Vorticella.
			Branched	Carchesium.
		Stalk inflexible............................		Epistylis.
	Bodies with different forms	Stalk inflexible		Opercularia.
		Stalk flexible, deflection spiral		Zoothamnium.

The following curious particulars relating to metamorphosis are appended to this family by Ehrenberg :—

"The *Vorticella* developes a pedicle; divides (casts its exuvia); developes posterior cilia; loosens itself from the pedicle, rambles about; draws in (after shedding a second exuvia) the posterior cilia, sheds them, and firmly attaches itself, in order to put forth another stalk and build a trunk. This cycle of phenomena is repeated again and again, and possesses high physiological interest; it is a returning circle of transformations, a return to an early condition similar to that of a butterfly, if it suddenly lost its wings and antennae, and again became a caterpillar, in order once more to return to the state of pupa and butterfly; or to that of an old man becoming a child, in order to run again his course of life anew."

Dujardin describes the *Vorticellina* under two phases of existence, in the first of which, they are attached by a contractile pedicle, and furnished with a wreath of cilia, interrupted at one point by the mouth; whilst, in the second stage, they for the most part become detached from their stalk, and swim freely about, whilst the anterior wreath of cilia disappears. At this stage some undulating filaments are developed, from the posterior extremity, as locomotive organs. In the first stage, again, the shape of the body is more or less conical, in the second, more elongated or cylindrical. The metamorphoses of *Vorticellæ* during their development, as likewise those of *Epistylis*, have been elaborately investigated by Dr. Stein, of Berlin, whilst those of *Zoothamnium*, have been as ably illustrated by our country-

man, Mr. Brightwell, of Norwich. Their several researches are given, with the special account of the genus to which they relate.

Of the several genera named and distinguished by Ehrenberg, two only are accepted by Dujardin, viz., *Epistylis* with a rigid pedicle, and *Vorticella* with a contractile stalk, simple or branched. "He would comprehend the genus *Carchesium* with the latter," for a generic character is not to be found in the simple or branched condition of the stalk, the bodies being similar. "As to the genera *Opercularia* and *Zoothamnium*, we have not met with them, having the character assigned by Ehrenberg." A third genus, under the name of *Scyphidium*, is established by us for the sessile species; whilst a fourth, *Vaginicola*, comprises all those species invested with a membranous sheath. Dr. Stein, in his researches on the development of *Vaginicola*, shows that the presence or absence of a pedicle is accidental, depending upon the stage of development, and that it cannot be employed as a generic distinction. This being the case, *Scyphidium* must merge with *Vaginicola*.

The genera *Stentor*, *Trichodina* and *Urocentrum* enter into the formation of the family *Urceolariens*, of Dujardin; and, on the other hand, the *Vaginicola* of this naturalist are placed by Ehrenberg in the family *Ophrydina*.

The *Vorticella* live for the most parts in sweet water, fresh, or marine, in which they are met with, attached to plants or shells to some Crustacea, or to larvæ of insects. There are, however, *Vorticellæ* and *Scyphideæ* produced in infusions, and even in fetid ones.

Genus Stentor.—*The trumpet Animalcules* comprehend ciliated tailless *Vorticellina* which have no pedicle or stalk, but are free, or attached by the posterior extremity of their bodies. The body is conical, but admits of very considerable modifications of form, and is entirely covered with cilia: a wreath of larger ones surmounts the forepart. The function of locomotion is performed by the cilia; the anterior wreath likewise constitutes a special organ for purveyance. Ehrenberg considers the longitudinal striæ along the body, and the circular ones at the anterior part, muscular fibres. The anterior wreath of cilia is coiled in a spiral form, about the mouth; and in some species a row of long ones proceed from the mouth, in a fringe-like manner, to the middle of the body, The nutritive

apparatus consists of numerous berry-like stomach-cells, connected together, and presenting a moniliform or necklace-like alimentary canal, which commences at the mouth, and, having made a detour through the body, returns to it. Oscillatoria, Rotatoria, and Monads, are often found abundantly in the stomach-cells. The Stentors increase by self-division, either longitudinally or oblique; and by ova, which form a net-like granular mass, cover the stomach-cells, and vary in colour in different species. There is, besides, a gland-like sexual body, resembling the soft roe of a fish, whose shape is band-like, moniliform, or round. A contractile bladder is also present. The Stentors are among the largest of the Infusoria, and all the species are visible to unassisted vision. They are best examined between the plates of a large live-box, a portion of the decayed stem or leaf on which they are found being put in with them.

"It is in the Stentors (says M. Dujardin), where we can view the several supposed internal organs isolately, that new observations will make known their real nature."

The Stentors are exclusively found in fresh standing water, or between plants where the water is still. They are coloured green, black, or clear blue.

Stentor *Mülleri.*—This is the white funnel-like polype discovered by Trembley; it is large, the crown or wreath of cilia interrupted, and the lateral crest or fringe indistinct. When swimming, the animalcule is usually contracted in the form of an egg, but when attached, it stretches itself out, like a trumpet. When several are swimming, in a glass vessel, they will gradually congregate, and select some particular spot, and then attach themselves, evincing, as it were, not only a degree of socialty, but (says Ehrenberg) a mental activity. These animalcules feed upon coloured food very readily; the ova are white, the spermatic gland moniliform. When kept a long time in cylindrical glass vessels they fasten themselves to the sides, form a slimy covering around themselves, and die. Found upon Lemna and other water-plants, even under ice. Size, stretched out, 1-20th.; contracted, 1-120th.

S. *Roeselii.*—In form, size, and crest, this resembles the preceding species, as shewn, elongated, at fig. 233; and contracted, as it swims, at fig. 234; the latter representation is rather more magnified. The

seminal gland is long, non-articulated, ribbon-shaped, as seen in the engraving. Above the gland are seen two of the stomach-cells, and the crest or fringe; at (*) is the contractile vesicle. In colour this species is more of a yellowish white than the preceding. Found upon decaying reeds, leaves, &c. Common, in summer, in standing water on stones. Length 1-140th; extended, 1-24th.

Stentor *cæruleus.*—Resembles, exteriorly, the two preceding species, but the ova are blue; the gland is articulated and chain-like, as seen in figs. 235 and 236, (plate 5). It is trumpet-shaped when extended, ovoid when contracted; white or semi-transparent, except when coloured by food. The lateral crest and frontal wreath, or crown of cilia, are continuous. When kept in glass vessels they often fix themselves to the sides in clusters. Self-division has not yet been observed. They are best examined under a microscope, when placed in a large live-box. A magnifying power of 100 diameters is sufficient. Found amongst Vaucheria. Length 1-480th.

S. *polymorphus* resembles the preceding in form. Ova of a beautiful green colour; gland articulated and chain-like; lateral crest indistinct; frontal wreath of cilia interrupted. This species will not receive indigo readily. Transverse self-division has been observed. Found upon stones, decayed sticks, and leaves, in standing water. Length 1-120th to 1-24th.

S. *igneus.*—Is less than the preceding; the ova are of a yellowish green colour; skin bright yellow or vermilion; gland spherical; lateral plume or crest absent; frontal wreath of cilia interrupted. Found by Ehrenberg upon the water violet (Hottonia palustris). Length 1-72nd.

S. *niger* (*Vorticella nigra,* M.)—Small, of a dark brownish-yellow or blackish colour; ova olive coloured; gland spherical; lateral crest absent; frontal wreath of cilia continuous. This species is often so abundant that it colours large pools, in turfy hollows, of a dark black hue, resembling an infusion of coffee. The swimming movement of this species is readily seen (as in the others) with the naked eye. Size 1-96th.

Genus Trichodina. *The urn Animalcules.*—Vorticellina destitute both of tail and pedicle. They are distinguished from the preceding

genus by the surface of the body being destitute of cilia; they possess a vibrating fasciculus or wreath of cilia anteriorly; the oral opening is simple, and not spiral. They are mostly disc-shaped or conical. Three species have a wreath of cilia around the anterior part, and on one side of its margin is a simple oral opening. T. *pediculus* has the posterior end abruptly truncated, like the front, and also surrounded with a wreath of curved setæ, which it employs as feet. In T. *tentaculata* there is a kind of proboscis. The polygastric structure can be demostrated in T. *pediculus* and T. *grandinella*, by coloured food; in the other species it may be observed without artificial aid. In all, the ova are clear and limpid as water. A kidney-shaped gland is seen in T. *pediculus.*

This genus, *Trichodina,* agrees in the main with that of *Urceolaria* (Duj.); but also includes "some *Keronia* (*Halteria*) with several doubtful Infusoria."—Dujardin, however, defines his *Urceolaria* as having the wreath of cilia extended spirally to reach the mouth; whilst in his *Trichodina,* that the oral opening is not spiral.

Many species live parasitic on fresh-water Mollusca, or Zoophytes; but others have been found in sea-water.

Trichodina *tentaculata.*—Body discoid, as shewn at P. 4, f. 227; it is destitute of the wreath of cilia, but it has a fasciculus of vibratile cilia, and a styliform proboscis, as seen in the engraving. Size 1-280th.

T. *Pediculus* (*Cyclidium pediculus,* M.) = *Urceolaria Stellina,* (Duj.) —Body depressed, of an urceolate and discoid shape, as shewn at figs. 228, 229, and 230; with a wreath of vibratile cilia anteriorly, and another of short moveable uncinate cilia, or hooked setæ, posteriorly. Ehrenberg remarks, "I have fed this species many times with indigo, and have seen numerous stomachs filled with the blue matter; it always runs upon the back, where there is a wreath of twenty-four to twenty-eight mobile hooks (or uncinate cilia), and has the mouth and vibrating wreath of forty-eight to sixty-four cilia directed upwards." It appears to feed upon the little granules of the body of the fresh-water Polypi (*Hydra*) drawn in Plate 7, of the *Microscopic Cabinet.* Figs. 228 and 229 are side views, attached to a portion of a polype; fig. 230 is a top view. Size 1-570th to 1-280th.

TRICHODINA *vorax*.—Body oblong, cylindrical, slightly conical; anterior part convex, and crowned with cilia; the back rather attenuated and smooth. Size 1-570th.

T. *grandinella* (M.)—Is nearly spherical; the back sharply attenuated; a wreath of cilia surrounds the truncated forepart. This species is liable to be mistaken, by an inexperienced observer, for a free *Vorticella;* its true character appears to be in its open wreath of cilia. Size 1-1500th to 1-860th.

We may here describe, owing to the general correspondence between the *Urceolaria* of Dujardin, and the *Trichodina* of Ehrenberg, two species of Urceolaria described by the former naturalist after Müller

Urceolaria *limacina* (*Vorticella limacina*, Müll.)—Sessile, cylindrical, diaphanous, sending out from its truncated orifice two to four cilia (difficult to be seen, says Müller); but we may rather suppose the broader anterior end to have a crown of cilia; whilst the narrower base, by which the animal is affixed, is furnished with the cilia described. Found on the tentacula and head of *Planorbis contortus* and *Bulla fontanalis*, by Müller.

Urceolaria—(*Vorticella bursata*, and V. *utriculata*, Müll.)—Dilated posteriorly, truncate and ciliated in front, of a green colour. Found in sea-water. Müller distinguishes two species; one having a papilla, capable of being extended in the form of a long neck; the other presenting a truncate front with a projecting papilla, from its centre, giving a notched figure to the animalcule when at rest.

Genus UROCENTRUM.—*The top Animalcules* are free, have a tail-like style, but are destitute of pedicle and cilia, except a wreath anteriorly; oral aperture simple. The internal organization, as far as it is known, is similar to that of the preceding genera. Perfect transverse self-division has been observed. Ehrenberg thinks the eyes, supposed to have been seen by Müller, were most probably the vestigia of some of the cilia, none of which he appears to have seen.

U. *turbo* (*Cercaria turbo*, M.)—Is hyaline, and has an ovate, trilateral body, with a style, or setaceous tail, one third of its length. Ehrenberg says, "The little tail is not a separable Vorticella-stalk, but an articulated style on the back—perhaps a foot. Found amongst Lemna and Conferva. Fig. 232 is a dorsal view, and 231 a side view. Size 1-430th to 1-280th.

GENUS VORTICELLA.—*The bell-shaped Animalcules* are crowned with cilia anteriorly, and have a pedicle or stalk, when young, but which, at a later period, and also after the first self-division, is wanting. Their shape, when pediculated, is similar; the pedicle can be suddenly deflected, spirally, by means of the long muscle within it, but it is never branched. The wreath of cilia and the long muscle, with the hollow pedicle, are the organs of locomotion. At certain periods a second wreath of cilia is produced at the posterior part of the body. Not only can numerous stomach-cells be seen, but likewise (according to Ehrenberg,) the gradual passage of the food onwards, in a twining sort of intestinal canal, though he says the latter is not easily observed, on account of the periodical deflection of the pedicle. But in the genera *Epistylis* and *Opercularia*, whose pedicles are comparatively motionless, the nutritive apparatus may be much more accurately investigated. The mouth and discharging orifice are separate, but lie in the same hollow, at the anterior margin. The propagative structures are variously coloured; clusters of ova, an elongated gland, and a round contractile bladder, exist; in fine, the animalcules are androgynous. The supposed increase by the growth of young animalcules out of the pedicle, like flowers on the stem of a plant, has arisen from erroneous observation. When the animalcule loosens itself from its pedicle or stalk, a circumstance, which (says Ehrenberg) "takes place at certain periods, the stalks die, or disappear, just like the shells of crabs, or as the nails and hair." The muscular fibre within the stem, requires stops, or an achromatic condenser, under the stage, to render it distinct.

The Vorticellæ being of so considerable size, and easily procurable, have formed the subject of numerous investigations into their organism; but yet no observers have been able to coincide entirely with the views of Ehrenberg. Among the most recent researches are those of Dr. Stein, of Berlin, which are devoted chiefly to the elucidation of the phases of development of Vorticellina; but which refer also to their general organization. Stein describes a canal, extending from the mouth into the interior of the body, and lined with cilia; this tube, however, does not curve on itself, so as to approximate its two extremities, but having advanced to about the centre of the body, ends abruptly by an open extremity, (P. 22, f. 1.)

During the passage of food through this gullet, it is seen to adapt itself to its calibre, by assuming an elongated or cylindrical form; but when it arrives at its open extremity, it assumes a globular figure, and is detached in the general homogeneous mass of the animal, as a free globule or vesicle, forming what Ehrenberg described as a stomach-sac. Besides the alimentary tube and globules, there are also seen, scattered, variable granules (ova, Ehr.) a contractile sac (seminal vesicle, Ehr.) and a ribbon or band-shaped, curved, and rather opaque body,—the testes, Ehr.—but which Stein calls the nucleus. (P. 22, f. 2.)

The commonly observed modes of propagation of the *Vorticellæ*, are self-division (fission) and gemmation; the latter the less frequent. When fission is about to proceed, the *Vorticella* contracts its body into a globular shape, draws its ciliated front within the body, whilst the nucleus assumes a transverse position, and an increase in the breadth of the animal proceeds. Division commences at the forepart of the body, but also soon evidences itself posteriorly; the nucleus in the mean while shows in itself signs of division, which increase, and ultimately the nucleus becomes like the body, divided in half. During this process, the fine granules of the interior disappear; a semilunar cavity is hollowed out at the anterior conical extremity (P. 22, f. 3) of each segment, with slowly vibrating cilia on its convex edge; this cavity is the rudiment of the future frontal wreath, into which it finally expands by being opened up anteriorly by a fissure.

When fission is complete, the appearance is that of two contracted Vorticellæ, seated on the same stem, and often placed at nearly right angles with one another (P. 22, f. 4.) The newly developed being further presents a furrow near its base, occupied by cilia; and by its movements, presently detaches itself from its fellow, and swims abroad freely, but with the previously hinder end forwards, the posterior wreath of cilia now forming its organ of locomotion. By and bye the new being comes to a stand still, fixes itself, pushes out a stem (P. 22, f. 2) the posterior furrow and cilia then vanish, whilst the common frontal wreath unfolds itself. These phenomena are briefly referred to in a preceding page, 520.

Propagation by gemmation takes place from one side of the base of

the parent; the bud is first egg-shaped, ovate, (P. 22, f. 1); but even when completed, does not attain the size of its parent. More than one bud may be in process of development, from the same individual, at the same time. In their course of growth, buds resemble the beings resulting from fission, both in the formation of the frontal wreath, and in the production and subsequent disappearance of a posterior ciliated zone.

These two modes of propagation are not peculiar to the most complete and largest animals, but appertain also to the smaller forms: this fact, together with the minute size and rudimentary character of vorticella-like forms in the vicinity of larger ones, led Dr. Stein to believe the existence of a third method of reproduction. He met with examples of V. *microstoma* from 1-76th. to 1-126th. of a line, and others from 1-190th. to 1-380th.; but in such there was no contractile stem, and they possessed but the general outline of form of *Vorticella;* yet between these extremes in magnitude there was every intermediate size (P. 22, f. 6, *a. b. c. d. e.*)

In the smallest specimens no anterior cilia could be detected, (P. 22, f. 6, *d. e.*); yet they could detach themselves from the granular mass to which they adhered, and swim freely about, extending and contracting themselves like larger forms.

Together with the various sizes of *Vorticella microstoma*, and amid the granular nidus in which they existed, Dr. Stein further found numerous nucleated cysts, 1-50th line in diameter, and about half the length of full grown *Vorticellæ.*

These cysts had a clear, double outline, and contained a homogenous, transparent, colourless substance, having mostly numerous granules. (P. 22, f. 5, 6.) These were in fact contracted *Vorticellæ,* each cyst containing a single being. In most, the characteristic band-like nucleus could be detected; in many, also, the involuted frontal wreath, with the oral cavity and gullet, looking like a fissure in the anterior part of the cyst; and, moreover, the contractile sac, yet active (P. 22, f. 5 and 7); on the other hand, he never observed the globules of food seen in the uncontracted (un-encysted) animalcules.

In other cysts, again, the frontal portion and alimentary tube could not be traced; but they possessed the contractile vesicle,—sometimes

divided, (P. 22, f. 8), and the nucleus. In others, lastly, all distinction of organs was lost; the nucleus being the last to disappear. (P. 22, f. 9.)

The process whereby *Vorticellæ* so retract themselves within their case, and become totally included within it, Stein calls the encysting-process. With this phenomenon before him, and the obliteration of organs witnessed, coupled with the fact of finding empty, rent cysts, Dr. Stein was led to believe, that, by the breaking up of special organs, and particularly by the peculiar agency of the nucleus, a granular germ-mass was developed, the several portions of which resolved themselves into spores, which subsequently escaped through a hole in the enclosing integument, and formed a granular sub-stratum similar to that to which he saw the rudimentary *Vorticellæ* adhering. (P. 22, f. 6, *d.*) and from which the elements of new forms seemed to be produced, these new forms finally passing through certain phases of development until they attained the characters of perfect *Vorticellæ*. (See p. 522.)

His subsequent researches, however, compelled Stein to set aside this hypothesis, for he found that *Vorticellæ*, like *Vaginicola* and *Epistylis*, after the encysted stage were transformed into Acineta-like individuals, and then assumed the figure of *Podophrya fixa*. Under this last guise an apparent, marvellous act of conjugation took place between two individuals; the coalesced beings continuing to be supported on their two pedicles. Beyond this point this curious history of the transformation of *Vorticella* has not been pushed. We may, however, refer the reader to the account of the metamorphoses of *Epistylis* by Dr. Stein, and would especially direct his attention to the previously published observations of M. Pineau, (see Part I., page 52) on the transitions of *Vorticella* into *Oxytricha*.

VORTICELLINA *nebulifera* (V. *nebulifera et convallaria*, M.)—The body has the form of a bell *(campanulate)*; the expanded part, answering to the mouth of the bell, being fringed with cilia; the pedicle or stalk, which is about five times the length of the body, is attached to the convex apex, which is rather conical, when the creature is in health but hemispherical when otherwise. The mouth is situated near the margin, where the wreath of cilia is interrupted. These creatures usually congregate together, though each is independent of its neigh-

bour; for on the approach of any foreign body to one, it withdraws, by coiling up its pedicle, while the others remain stretched out in search of food. The pedicle is not contracted, but merely deflected, by means of the long muscle within it, so that it can form as many as ten coils, like the spring of a bell. The body of the animalcule does not contract or become wrinkled, but the ciliated margin appears sometimes bent inwards. In colour, when seen in masses about the roots of Lemna, they appear white. An amplification of 300 diameters is necessary to exhibit the cilia. Longitudinal self-division may often be observed, during which the body becomes broader. Gemmae, or buds, shoot out from the sides of the other species, but have not been noticed in this. Found abundantly on the stalks of Lemna and other water-plants, even in winter under ice. Length of body 1-570th. to 1-280th.

Vorticellina *citrina* (M.)—The body is more hemispherical than the preceding, and the frontal margin more expanded. Found upon Lemna, rarely with the former species. Length of body 1-430th. to 1-210th.; stalk three to four times that length.

V. *microstoma*.—Has an ovate body, attenuated at both ends, and having the frontal margin narrow, not expanded. The body, during contraction, is annulated; its colour whitish-grey. The mouth, stomach, reception of coloured food, male glands, ova, and long muscle of the stalk, have all been observed in this species, as also spontaneous longitudinal and transverse self-division, and the growth of gemmæ. Ehrenberg counted from twenty to twenty-four cilia in the frontal wreath. Found in stagnant water. Length of body 1-2300th. to 1-240th.; length of stalk six times that of the body.

V. *campanula* (*Vorticella lunaris*, M.)—Body hemispherical, bell-shaped, with the frontal margin broad and truncated; not expanded. Colour whitish-brown. (ring, none.) This species forms a thick bluish matter upon water-plants, and the single animalcules are discoverable with the naked eye. Size 1-120th.; stalk seven times longer than the body.

V. *hamata*.—Body small, ovate, hyaline, attenuated at both ends; pedicle obliquely attached to the body, so as to form something of a fish-hook appearance. Length of body 1-570th.

VORTICELLINA *chlorostigma* (*Vorticella fasciculata*, M.)—Body green, ovate, conical, campanulate, and annulated (wrinkled). The frontal margin is expanded; the cilia contractile bladder, and green ova, are to be seen, but the seminal gland, self-division, and growth of gemmæ, have not been observed. In water this creature often covers grasses and rushes with a beautiful green layer. Length 1-240th.; stalk five times the length of the body.

V. *patellida* (M.)—Body hemispherical, campanulate; frontal portion very much dilated; its margin expanding greatly, and often reflexed. Length 1-480th.; stalk about seven times the length of the body.

V. *convallaria* (V. *craterformis, citrina, gemella, globularia, hiaris, nasuta et truncatella: Enchelys fritillus, Trichoda gyrinus*, M.)—Body ovate, conical, campanulate; frontal portion dilated, and its margin slightly expanded. It is annulated, and of a hyaline or whitish hue. This appears to have been the first infusorial animalcule discovered. Leeuwenhoek, the discoverer, found it in stagnant rain-water, at Delft, in April, 1675. It is found in considerable abundance, upon the surface of vegetable infusions, with V. *microstoma*, from which it is distinguished by its broad front, which gives to it a bell-shaped or campanulate appearance. Carus, in 1823, represented it as arising from spontaneous generation in oil, or an accidental mixture of oil colour and spring water; but Ehrenberg remarks, the appearance arose in a very natural way. It has been described under various names by different naturalists. Ehrenberg gives thirty-eight references to different works treating on it. Figure 237 (plate 5.) is a group of three, with the pedicle of another, to shew the manner in which it is deflected spirally. Figures 238 and 239 two stalkless creatures; from their different appearances in the latter state, Müller has described them not only as different species, but under different genera. In *Die Infusionsthierchen*, there are eighteen names under which that author has described them. Length 1-430th. to 1-24th.; stalk six times its length.

This entertaining and well-known animalcule is usually found attached to any extraneous body, as the leaves of duck-weed, small aquatic shells, clusters of the ova, or the larvæ of insects; an example of the latter is shewn in the *Microscopic Illustrations*, fig. 30, where

it may be considered as a *parasite*, or rather an *epiphyte*. As they are, when fully developed, attached mostly to some stationary object, they afford many facilities to the microscopist for observation; they form a good object also for ascertaining the defining power of his instrument, and his expertness in its management, as much of the effect will depend on the manner in which he manages the illumination. If this be not attended to, and the instrument has not sufficient power and penetration, it will only exhibit two cilia instead of a circular row; indeed, this animalcule is described and drawn in this manner by the old authors, an error which recent improvements in the microscope have demonstrated.

When in search of prey they stretch out the stem, and by means of a vibratory motion communicated to the cilia they agitate the water, and occasion a current towards them; this brings along with it the small particles of matter on which they feed. Should any circumstance disturb the water, or a large animal approach them, they instantly retract, bending the stem into a number of coils; this operation is performed so quickly, that the eye cannot detect it; in a few seconds, the creature may be observed slowly uncoiling the stem. These curious animalcules are endowed with several methods of propagation, the observation of which has thrown much light upon this interesting subject, and enlarged our views of the operations of Nature in her minute productions: many creatures, which we formerly considered as belonging to distinct genera, are now ascertained to be the same in different conditions. One method of increase is probably from ova; but of this we have no direct evidence. Dr. E. considers that the spawn is ejected, as with *Kolpoda;* the first appearance of the young is like several little specks, rather darker than the surrounding mass, and possessing a tremulous motion; they are then not more than the 1-12000th. of an inch in diameter, and are clustered about the roots or stems of the old ones; they do not change their situation, and are probably connected to the parent group by invisible filaments; they soon increase in size, when delicate stems may be perceived, as may also a current in the water towards the bell, indicating the presence of cilia. At this stage of their growth, they have been considered as a distinct species

by Schrank, under the title of V. *monadica,* because at this period the stems do not contract spirally, as in the old ones. From some of the specimens observed by Müller, it is evident that they are also produced by buds.

The next method of propagation is by a division of the parent. When this is to be effected longitudinally, the bell increases in breadth; a separation then commences, and two circles of cilia are formed; the body of the animal then divides, and other cilia grow around the dome of the bell; by constantly whirling, one or both of the bells separate from the stem, and swim about, in which condition they have been classed as a distinct genus, under the name *Urceolaria.* Should it happen that both the bells are twisted off, the stem remains stationary, and does not contract afterwards, or produce a new bell. The most striking peculiarity which next presents itself is, that the end formerly attached to the stem swims foremost, and from the other extremity proceeds the new stem; before, however, this is effected, it changes its form, and sometimes buds out, or separates; the latter is the genus *Eclissa* of Schrank, and the former, with the small protuberance, *Rinella* of Bory St. Vincent. If the creature retain its bell-shape, be not inverted, and exhibit the lower cilia, it forms the genus *Kerobalina* of the latter naturalist, and when all the cilia are invisible, then it forms his genus *Craterina.* Again, it constitutes the genus *Urceolaria,* when the anterior cilia are alone observed. Besides those already mentioned, there are many other changes in its form; sometimes it stretches itself out in length, and becomes cylindrical, so that it is readily mistaken for a species of the genus *Enchelys;* in this condition, one or both ends bend themselves, while it is swimming past a hard body; finally it separates transversely in twain.

The next method of propagation is by the formation of buds, and is common both to the animalcules with, and to those without, a stem. During this process it passes through a variety of shapes, moves briskly in the water, and forms the genus *Ophrydia* of Bory St. Vincent. Ehrenberg has divided this species into two varieties, founded on the shape of the bell; when they are nearly globular, he calls them V. *campanulata;* when pointed, V. *pyriformis.*

V. *picta.* — Body ovate, conical, campanulate; frontal portion

dilated, and its margin slightly expanded. The pedicle is very slender, and curiously marked throughout its length with red dots. Length 1-1150th to 1-570th; stalk four to five times as long.

Genus Carchesium. *The tree and trumpet Animalcules* are closely allied to the preceding genus, from which they are distinguished by having their spirally flexible pedicle branched, in consequence of imperfect self-division. The bodies upon the pedicle are all of the same form. The organization of this genus is not so well known as that of *Vorticella* and *Epistylis.* A simple wreath of cilia, which during quick vibration appears double, is observable; and another, at certain periods, at the posterior part of the body; within the pedicle, a transversely folded thread-like muscle is observed during contraction; the mouth (which is lateral), and a polygastric alimentary canal are distinct. Of the propagative system, whitish ova, granules, and a contractile bladder, are seen; but a spermatic gland is not very distinct. Imperfect longitudinal self-division is a very marked character; the growth of the gemmæ has been observed, and the periodical separation of the body from the stalk gives rise to free animalcules, as in *Vorticella.*

C. *polypinum* (V. *polypina,* M. and Duj.) of Leeuwenhoek has a conical, campanulate body, the frontal portion broad, truncate, and the margin expanded. Colour white; pedicle branched, the division being sub-umbellate. The stomach-cells are easily discerned when indigo is mixed with the water, and the mouth is thus indicated by the particles congregated near it. The reception of coloured food into the œsophagus is observable; but its passage from one digestive sac to the other is so quick, that the alimentary canal has not been seen and traced as a continuous tube; it is similar to the act of swallowing in large animals, the food not remaining for any length of time in the œsophagus before it passes into the stomach. Figs. 240 to 245 represent tree-like clusters, except fig. 244, which is a single free animalcule. Figs. 240 and 241 are only slightly magnified; the latter exhibits an animal contracted. In figs. 242 and 245, as also the free pedicle, fig. 243, the muscle is very distinct. This muscle was first observed by Mr. Varley. Size 1-570th to 1-430th; ova granules 1-24000th.

C. *pygmæum.*—Body very small, ovate, white, rather dilated in

front, pedicle branched in a trifid, rarely in a trifid manner. Body 1-2400th. Berlin. On Cyclops quadricornis.

CARCHESIUM *spectabile*. — Body conical, campanulate, dilated in front; branching in an oblique conical figure, attaining two lines in height. Berlin.

Genus EPISTYLIS. *The pillar Animalcules.* — *Vorticellina* with a rigid pedicle, either simple or branched, and having all the corpuscles of the same figure; or, in other words, they are *Vorticellæ* or *Carchesia* with a rigid pedicle, and without an internal muscle. The pedicle, or stalk, appears to be a hollow tube. The polygastric structure, and the situation of the united mouth and anal opening, are easily demonstrated by the employment of coloured food. In E. *plicatilis*, the whole course of the alimentary canal can be seen. The granular ova, says Ehrenberg, have been measured in several species; a contractile bladder, and a short band-like male gland, are observable in many; the latter, however, is spherical in E. *nutans*. Longitudinal self-division has been seen in E. *anastitica*, E. *galea*, E. *plicatilis*, E. *flavicans*, E. *leucoa*, E. *digitalis*, and E. *nutans;* and it is probable that the free forms transversely divide. In E. *nutans* and E. *plicatilis*, gemmæ have been seen; but these are never produced by the stalk.

The Epistylidæ are among the largest of the Vorticellina; and are exclusively found in pure water, on aquatic plants or animals.

The researches of Dr. Stein have made us well acquainted with the organization of *Epistylis*, and especially with a peculiar mode of propagation by a metamorphosis or an "alteration of generation.' The subject of his observations was the E. *nutans* (P. 22, f. 16), of which he well displays the ciliated frontal apparatus of two lips, with a wide oral cavity between them. These so-called lips, when protruded, doubtless are the organ alluded to by Ehrenberg, as the projecting velum palati (gaumen segel). But the animal possesses the power, like a Rotifer, of withdrawing these ciliated whorls, and when this is accomplished, the double character of the lip vanishes and is replaced by an apparent single ciliary cylinder, or whorl (P. 22, f. 18). The mouth opens into a large oral cavity, or gullet, extending half the length of the body, and continued by a very narrow prolongation, as an alimentary canal, nearly to its attached

base. Close to the bottom of the oral sac lies a contractile vesicle, and near this a larger finely granular spot, well defined, and higher up than this again, a similar but smaller spot. The two latter spots are the opposite extremities of the band-like nucleus, lying on one side the mouth.

The stem or pedicle is inflexible, and apparently hollowed internally by a canal; the animals seated on its branches have considerable latitude of motion by their mode of articulation; and they also are able, in some degree, to shorten themselves by the annular segments of their base.

Both animals and pedicles undergo spontaneous fission, which happens just as in *Vorticella;* however, the new forms produced, do not, in *Epistylis,* develope posterior cilia, but progress by means of their usual frontal apparatus.

All the members of the same little-tree (polypidom) are of nearly equal size; the largest noticed were 1-20th. of a line in length; whilst in other polypidoms, whose stems and branches were proportionately thinner, examples were met with of very minute size (P. 22, f. 22, 23). In the smallest, no anterior cilia, and no contained globules were visible; in larger ones, though only 1-150th. of a line in length (P. 22, f. 23) such were found. These latter forms constitute the *Epistylis Botrylis* (Ehr.)

Besides fission, Dr. Stein presumes *Epistylis* has another mode of generation by metagenesis, wherein it is transformed into an acineta-like individual, which again becomes the parent of ciliated vesicular embryos. The change of an *Epistylis* into an *Acineta* has not been actually witnessed, and neither is the further history of the subsequently developed, ciliated embryo cell, known. But Dr. Stein rests his opinion chiefly upon an analogy with *Vorticella* and *Vaginicola,* in which he has actually seen the transformation into *Acinetæ,* and also upon the similarity of the pedicle, and the movements of the Acineta body upon it.

The supposed *Acineta* of *Epistylis nutans* appears to have escaped notice, although of common occurrence at all seasons of the year, even under the ice, growing upon duckweed and other aquatic plants (P. 22, f. 18). The normal shape of the *Acineta* is ovate or pyriform (P. 22, f. 17, 18); but may be variously and greatly

modified by contraction (figs. 19, 20, 21.) The largest are not above 1-24th of a line in length; the smallest 1-100th. The enclosing tunic is elastic and colourless, and stronger behind than in front. The divergent fibres are disposed in two bundles, one at each anterior angle; (fig. 16), they enjoy a considerable degree of motion; and often, by their intertwining or crossing, entangle small Infusoria or other bodies.

In many large Acineta forms, the divergent fibres are wanting (fig. 17); such probably are in an earlier stage of metamorphosis; and subsequent to the completion of the encysting process of the original *Epistylis*.

The Acineta-bodies have no mouth; it is indeed difficult, from the toughness of their tunic, to effect a rupture; no food or stomach sacs, likewise, can be found in them, their substance being homogeneous, granular, soft, and containing, besides its very fine granules, some larger globules, probably of oil (fat), a contractile sac anteriorly, and an elliptic discoid granular nucleus, often accompanied by another smaller, finely granular, discoid globule, well defined. Both nuclei are seen in fig. 18.

The larger nucleus is the one destined to undergo the first change; this it does by the development of fine cilia around its periphery, which actively vibrate, and so cause its rotation. Whilst this goes on, it increases in size, advances towards the anterior of the Acineta, which takes on active contractions, and thereby ultimately ruptures its integument, allowing the embryo (ciliated nucleus) to escape. On its emergence, the embryo swims away rapidly by means of its cilia: what further changes it undergoes it is yet to be discovered.

However, the part the Acineta-body has to perform, is not completed by the production of the one embryo; but the same process is to be repeated again and again, until its formative granular mass is used up, when the Acineta becomes a contracted, shrivelled, empty sac (as seen in fig. 21), seated upon the persistent stalk.

After the emission of an embryo, the Acineta-body contracts strongly; some of its diverging fibres shorten, whilst others are entirely withdrawn. This contracted condition, after lasting for a time, relaxes; the Acineta resumes its usual movements, the fibres spread out anew, moving about as usual, in various directions; and it finally regains

its original characters, save that it is smaller, and instead of a smooth, even surface, it has its tunic thrown into folds or undulations (fig. 19). The spot from whence the embryo escaped, soon becomes imperceptible.

The embryonic being developed from the Acineta-form stage of *Epistylis anastatica*, is similar to the *Trichodina grandinella* (Ehr.), and probably is identical with it. Besides the Acineta condition of E. *nutans* and E. *anastatica*, discovered by Stein, that of E. *Grandis*, E. *Berberiformis*, E. *Barba*, and of E. *plicatilis*, has also been noticed, less certainly, by the same observer.

Epistylis *galea*.—Large, body conical, contractile by transverse folds; mouth lateral and projecting; pedicle thick, branched, and articulated. Found upon Ceratophyllum. Size of body 1-120th.

E. *anastatica* (*V. anastatica cratægaria et ringens*, M.)—Body oval, without folds; frontal margin dilated and projecting; pedicle dichotomous, smooth, or squamous, with foreign particles. Stomach-cells, and a united mouth and anus, are observable, but the alimentary canal has not yet been seen. The granules of ova are white by reflected, and yellowish by transmitted light. The clear vesicle is often to be seen, but not its contraction. Growth of gemmæ unknown; self-division longitudinal. Found upon Ceratophyllum, and also upon small water Mollusca. Size 1-280th.; heighth of little tree 1-140th.; ova 1-12000th; range of development 1-12,000th to 1-280th.

E. *plicatilis* (*V. annularis et pyraria*, M.)—Body conical and elongated, contractile in folds; frontal margin dilated, truncated, and slightly projecting; pedicle dichotomous, smooth, or, when foreign bodies adhere, having a scaly appearance. It is often corymbose. This species is white to the naked eye, but somewhat yellow beneath the microscope; it is very much like the preceding, is often found with it, but is distinguished by being larger, by its ring-like folds when contracted, and by the tasselled or tufted appearance of the cluster. Size 1-280th. to 1-210th.

E. *grandis*.—Body broadly campanulate, stalk decumbent, slender, smooth; the branches flexible and without articulations, but much tufted. This is not only the largest fresh-water species of *Epistylis*, but it also forms the greatest masses. Its proper colour is a blueish white, but it often appears of a yellow or greenish hue, from the

colour of its food. Found upon *Ceratophyllum* and *Nymphæa*, often in masses several feet long, and two to three inches thick; it appears like a bluish-white slime, which is easily broken up. Size 1-140th. to 1-120th.

Epistylis *flavicans* (*V. acinosa et bellis*, M.)—Body large, broadly campanulate; pedicle smooth, its branches coarctate. The branches are dilated at the axillæ, and the ova are of a yellow colour. In this species, the alimentary canal is very evident. Size (stretched out) 1-190th.; tree 1-9th high.

E. *leucoa* (*Volvox sphærula*, M.)—Body large, broadly campanulate; pedicle erect, smooth, and articulated; the branches capitate or collected in a head; ova white. These animalcules are convex anteriorly, have distinct ova granules, a simple wreath of cilia, and a round mouth at the margin. The seminal gland is bent in the form of the letter S. Size 1-120th; tree 1-24th; ova 1-5760th to 1-6000th; range of development, consequently, 1-600th to 1-120th.

E. *digitalis* (*V. digitalis, ringens et inclinans*, M.)—Body small, cylindrical, campanulate, dichotomous, and finely annulated. This well-marked form infests the *Cyclops quadricornis*, drawn and described in the *Microscopic Cabinet.* It sometimes completely envelopes it. Ehrenberg says it does not appear to be deadly to it; but I consider it a disease. In the beautiful little tree this species produces, the *Notommata petromyzon* nestles just like a bird in a bush, and fastens its eggs to its branches. Coloured food is readily taken, and fifteen large stomach-cells have been counted. Size 1-430th; tree 1-20th.

E. (?) *nutans.*—Body ovate, attenuated at both ends; mouth distinctly two-lipped and prominent. The pedicle is branched and annulated (see fig. 245 and 246; and P. 22, fig. 16, 22, 23.) "This animalcule (says Ehrenberg) can push forth a bladder between its lips, like (si parva licet componere magnis) a camel can its palate-veil (gaumen segel)?" Size 1-430th; tree 1-24th.

E. *botritis.*—Body very small, ovate, crowned with cilia. They resemble grapes upon a simple hyaline pedicle. Size 1-2400th; tree 1-240th. (See Stein's remarks, p. 536.)

E. *vegetans* (*Volvox vegetans*, M.)—Body very small, ovate, crowned with cilia (?); disposed in clusters, like the preceding, upon a bran-

ched pedicle, of a yellow colour. When the water containing this species is coloured with indigo, strong currents are seen at the front or head of each animalcule, caused by a vibratile organ, also observable; but whether the latter is a wreath of cilia or a simple proboscis, is undetermined; if a proboscis, this creature would belong to the Monads, where it would form the type of a new genus. Found in river-water. Size 1-3450th; tree 1-140th.

Brightwell says (Fauna Infusoria of Norfolk, 1848) the armed or oral animalcules are furnished with a long filament, that when the water is shallow, they detach themselves, and swim about with a revolving motion. The organ of motion, he states to be a long filament (proboscis.)

Epistylis *parasitica.*—Body small, conical, campanulate, and solitary; pedicle simple and smooth. Found upon Zoobotryon pellucidus. Length 1-570th; with pedicle 1-120th to 1-24th.

E. *Arabica.*—Body small, oval, campanulate; pedicle but little branched, smooth, and hyaline. Found in the Red Sea. Size of tree, 1-140th.

E. *Barba.*—Body ovate, oblong, white; branches dichotomous; longitudinally and regularly striated. Found on Larvæ of insects.

E. *berberiformis.* — Body oblong, sub-cylindrical, white; stem dichotomous, articulated, and striated, its divisions dilated at their apices. Found also Parasitic, Berlin.

E. *euchlora.*—Body oblong, rather expanded in front, with green ova; stem branching, dichotomous, 1-13th inch in height, smooth. Parasitic, on Planorbis cornea, Berlin.

E. *pavonina.*—Body very large, helmet-shaped, elongated in front; stem very high, dichotomous, striated, and hence decomposing light, and displaying many hues. Often 1-3rd inch in height. Berlin.

Genus Opercularia. *The parasol little bell Animalcules* have a stiff rigid pedicle, branched, from imperfect spontaneous division. The pediculated corpuscles are of different forms; they have two lips—the superior one, supported by a muscle, is somewhat like a parasol, or lid (operculum) which is a characteristic. *Opercularia* = *Epistylis* with dissimilar corpuscles. The organs of locomotion consist of a wreath of cilia, and a long muscle within the body; this rises or depresses the frontal surface, in the form of an upper lip.

At the large, lateral, somewhat anterior mouth, to and from which the alimentary canal is seen running, the discharge of matter also takes place. They are hermaphrodite; self-division, and free separation of the body from the stalk, have been observed. It is very remarkable that below its proper bodies, more especially in the axillæ of the branches, there are seen large single bodies, and even larger egg-shaped ones, having hairs at their point, and only a small round, but not vibratile opening. The latter ones are most probably parasitical bodies, the others are not. This genus is not figured by Ehrenberg.

OPERCULARIA *articulata* (*V. Opercularia*, M.)—Occurs as a little shrub, 1-6th to 1-4th high, white and dichotomous. This animalcule readily takes in carmine and indigo; and Ehrenberg states, he saw as many as forty-four stomach-cells filled, resembling a girdle in the middle of the body. The stalk is very delicately striated in a longitudinal direction, and shews, at its divarications, a transverse line, or joint. Found upon Dyticus marginatus. Size 1-430th.

Genus ZOOTHAMNIUM. *The double-shaped little bell Animalcules* comprehend *Vorticellina* with a flexible spiral pedicle, having an internal muscle, and becoming branched, from imperfect spontaneous division. The stalked corpuscles are of different shapes, and have a simple, lateral, oral opening. In one species, a wreath of cilia placed around the frontal region, constitutes the locomotive apparatus; and a special muscle or fibre runs along the branches and stem. Artificial means are able to demonstrate numerous round stomach-cells. No reproductive organs have been detected; but simple and compound self-division have been observed.

Z. *arbuscula* (*Vorticella racemosa*, M. and Duj.)—Has the branches of the little tree in racemes or umbels; the corpuscles being white, and the pedicle very thick. (See fig. 247, which is more highly magnified than 248). These beautiful little trees resemble plumes of feathers, at once distinguishing themselves by their strong branches, but having the characters of *Carchesium* and *Opercularia*, as respects the presence of globular bodies in the axillæ of the branches. When full grown, all the animalcules free themselves from the pedicle, which afterwards withers and disappears. Found upon Ceratophyllum, stalks of the water lily and of other aquatic plants; it is visible to the naked eye. It contracts itself on every alarm, by the muscle which runs

down the sheath. It lives but a short time when removed from its native place—Brightwell. Size 1-430th; tree 1-4th; stalk 1-4th. the thickness of the body.

We are happy to quote the valuable observations of our countryman, Mr. Brightwell, of Norwich, as given in his original little work, entitled Fauna Infusoria of Norfolk, 1848.

"Sept. 16th, 1846. Early in the morning of this day, we observed one of the *Zoothamnium arbuscula*, a large old specimen, which had lost all its small bell-shaped animals, but had several medlar-shaped buds or ova remaining upon it. It was seen to detach from its stalks nearly all these ova, which went off as free animals; one of them soon after settled at the side of the water-trough, and after agitating its anterior cilia, it suddenly, and with a kind of violent effort, opened into a cup-shaped form, and darted about with great rapidity, occasionally settling, and darting off again.

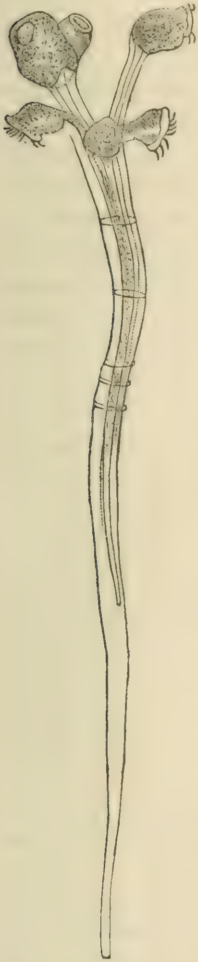
"At nine in the morning, one of these buds, or ova, was observed fixed to the glass by a sheathed pedicle, a ciliary motion became perceptible at the top of the bulb, and at ten it had divided longitudinally into two buds, each supported by a short stalk. The ciliary motion continued in the centre of each of these two buds, which by degrees expanded longitudinally, and at twelve had become four buds. By four, P. M., these four buds had divided in like manner and increased to nine, with an elongated foot stalk, and interior contractile muscle.

"During the development of another specimen, the stalk appeared to have transverse ribs or joints, and whilst a drawing was making, gradually bent downwards, and all the buds severally detached themselves from it, and went off as free animals, leaving only the bent stalk. "In this interesting process we see something analogous to what Steenstrup describes as 'a mode of development by means of nurses or intermediate generations.'

"This mode is described as that in which an animal produces a progeny permanently dissimilar to itself, but which progeny produces *a new generation* in itself, or its offspring, returning to the form of the parent animal. It will be seen that this development differs from that of metamorphosis, in the circumstance of the intermediate animal (the nurse) being itself a permanent and producing form.

"To shew this to be the case with *Zoothamnium*, it would be

necessary to prove that the medlar-shaped animals were a permanent form, producing a race, which in themselves, or in what they produced, returned to the form of the parent animal.



"We have not been able to carry the development of these buds or ova further than P. 15, f. 67, 68, 69, and wood cut. And it is remarkable that in all these the buds have produced, not the little bell-shaped animalcules, like the parent animal, but other buds like themselves. May it not be the case, that these medlar-shaped bodies are propagated at the close of the year; and that, when the plant to which the Zoothamnia bearing these bodies are attached, die away, they remain in the mud, protected by the cold of the winter, and in the spring burst forth, and settle upon the new growing plants, and produce animals of the parent-form. They would thus form an intermediate nursing race answering to Steenstrup's description."

ZOOTHAMNIUM *niveum*.—Branches short, alternate, and almost verticillate; bodies oblong, white, clustered at the ends of the branches; some are round and attached to the trunk; the branches are filiform, the lower ones often deserted, while the upper bear clusters of club-shaped little bodies, rounded anteriorly. Size 1-210th.

The genus *Scyphidium*, appended by Dujardin to the family of the *Vorticellina*, is thus characterized:—

SCYPHIDIUM.—Body sessile, cup-shaped, tapering at the base, covered with reticulated integument.

S. *rugosa*.—Body oblong, marked with distant oblique striæ, deep, and looking like furrows. Length 1-565th. Found in pond-water, amongst vegetable debris. To this genus Dujardin would attach the *Vorticella ringens*, and V. *inclinans*, of Müller, and possibly also the V. *pyriformis*, of the same author.

Family.—OPHRYDINA.

Comprehends loricated polygastric animalcules, solitary or aggregate, possessing a distinct alimentary canal, a separate mouth and discharging orifice, which approximate and terminate in the same spot. In organization it resembles the family *Vorticellina;* in fact, says Ehrenberg, it includes true *Vorticellæ* or *Stentores*, inclosed in a gelatinous membranous combustible little box (shell.) The locomotive apparatus consists of a frontal wreath of cilia; the genus *Ophrydium* has a second wreath placed posteriorly, and *Tintinnus* an elastic muscular stalk or tail. Although the polygastric organs of nutrition can be demonstrated in all the tribe by using coloured food, only in *Ophrydium* has an alimentary canal been distinctly seen by Ehrenberg. In *Vaginicola* and *Cothurnia* longitudinal division of the body without the lorica has been observed. In *Ophrydium* transverse division without the lorica is known.

The genera are disposed as follows:—

Forming Monad clusters, through incomplete self-division of the lorica			Ophrydium.
Single animalcules, no self-division of the lorica	body furnished with an elastic pedicle attached to lorica.		Tintinnus.
	body stalkless.	lorica stalkless	Vaginicola.
		lorica stalked	Cothurnia.

The genera composing this family are otherwise arranged by Dujardin, the *Ophrydium* (Ophrydia, Duj.) with the *Urceolaria*, and *Vaginicola* with the *Vorticella.* This author writes:

"The so-called lorica of *Ophrydia* is an amorphous gelatinous investment, unlike that of *Vaginicola*, which is a truly resistant enveloping membrane. The individual beings in the gelatinous ball of *Ophrydia* are elongated, cylindrical, or fusiform, and capable of varying their figure."

Further, the genus *Vaginicola* of Dujardin, includes, besides, the genus of the same name in Ehrenberg's arrangement, *Tintinnus* and *Cothurnia.*

Dr. Stein says, (Archiv. für Naturgeschichte, 1849) that the members of *Vaginicola* are not actually or necessarily without pedicles, and cannot be rightly separated from *Cothurnia*. From the tenor of his essay, it may be also gathered, that he regards *Vaginicola* as a genus of the family *Vorticellina*. To the same industrious observer, we owe some very accurate researches into the organization and reproduction of *Vaginicola*, which are detailed in the account of that genus.

Genus OPHRYDIUM. *The gelatinous little bell Animalcules* possess a gelatinous lorica, and are clustered (resembling gelatinous balls), in consequence of perfect self-division of the body, but imperfect of the lorica. This circumstance gives rise to very peculiar external appearances, for each body very frequently divides itself, the two portions separating entirely; the gelatinous lorica forming only a separating wall. In this manner thousands and millions of connected animal cells are quickly formed, appearing as gelatinous masses. They resemble minute Algæ of the genus *Nostoc*, and have been placed with Ulva, Fucus, Conferva, &c., by different botanists.

O. *versatile* (*Trichoda inguillanus et Vorticella versatilis*, M.) —Has elongated corpuscles, attenuated at both ends, vividly green, and associated in smooth and globular polypi clusters or masses, which vary in size from that of a pea to that of a ball five inches in diameter; they are either free or attached. Ehrenberg states, that in May, 1837, he saw hundreds of clusters as large as the fist, which, by the evolution of gas, were at intervals elevated to the surface, and driven by the wind to the edge of the water. Longitudinal self-division has been seen by the same observer, and he is inclined to believe that Schrank's representation of transverse division is erroneous; figs. 249, 250, represent quarters as small globular masses of clustered animalcules not magnified. Figs. 251 and 252, parts of such a mass magnified; and figs. 253 and 254 single animalcules, in the former stretched out. Found in sea-water. Found by Brightwell in fresh-water, also in a small turf pit, upon tendrils of roots of marsh plants, as also upon the stalks of the white water-lily. Length of single animalcule, stretched out, 1-120th.

Genus TINTINNUS. *The clapper little bell Animalcules.*—*Ophrydina* which possess divisibility of the body, but not of the urceolate lorica;

the body is attached to the interior of the lorica by a flexible pedicle (somewhat similar to the clapper of a bell.) The organs of locomotion are a wreath of cilia and an elastic pedicle; the mouth serves both as a receiving and discharging orifice; and stomach cells, traces of a yellowish ova cluster, are more or less visible; self-division was known to Müller.

TINTINNUS *inquilinus.*—Body hyaline or yellowish coloured; lorica cylindrical, glass-like, bell-shaped. (See group 255.) Length of body, without the stalk, 1-570th; with, 1-240th. In sea-water on Algæ.

T. *subulatus* (*Vorticella vaginata,* M.)—Body hyaline, lorica conical, with a posterior subulate elongation. Ehrenberg observes, that if this elongation or pointing of the lorica should be called a stalk, we should require a new generic name for the animal. Length of lorica 1-90th.

T. *cothurnia.*—Body hyaline, lorica cylindrical, hyaline, indistinctly annular; rather attenuate and truncate posteriorly. Size 1-440th. In the Baltic.

T. *campanula.*—Body hyaline, lorica widely campanulate, dilated in front, pointed behind. Size 1-290th. In North Sea and Baltic.

T. *denticulatus.* — Lorica cylindrical, hyaline, sculptured with oblique rows of dots, front margin acutely dentate; posterior extremity pointed. Size 1-220th. In the North Sea.

Genus VAGINICOLA. *The Sheathed little bell Animalcules* comprehend *Ophrydina,* distinguished by divisibility of the body, but not of the lorica, and neither of the two pediculated; a wreath of cilia surrounds the truncated frontal portion, within which, at the margin, is the orifice or mouth. The polygastric apparatus, the passage of the food onwards, its return, and the exit of the refuse near the mouth, have been seen by Ehrenberg. One species (V. *crystallina*) has coloured ova granules. No other reproductive organs have been observed satisfactorily. Increase by longitudinal self-division has been seen in all the species.

In all the particulars of internal organization, says Dr. Stein (Archiv. für Naturgeschichte, 1849), *Vaginicola* resembles *Vorticella,* except that its nucleus is discoid, not band-shaped, as in the latter. Propagation by fission and gemmation is likewise very distinct; by

the former process more commonly (P. 22, f. 10, 11.) The development of the bud takes place from the base of the parent, and within its sheath. The young being, produced by either process, is furnished, as in *Vorticella,* with a posterior wreath of cilia, whilst it is endowed with free locomotion (P. 22, f. 11.) It frequently happens, as represented in the last quoted figure, that the new being formed assumes a contracted ovoid form, with its frontal wreath retracted. Upon the appearance of the posterior whorl of cilia, and aided by their movements, the young animal loosens itself and escapes from its parent case, and swims freely away, elongating itself, it may be, if previously contracted, and assuming finally all the characters of a perfect *Vaginicola,* by developing around it its own special sheath.

On the other hand, the contracted individual may become actually encased within its integument, in other words, encysted, and pass through a peculiar cycle of changes, by assuming all the characters of an *Acineta.* In the encysting process, the animal sinks towards the bottom of the case produced around it, and thus drags on its anterior part, bringing the sides of its original opening into approximation. In effecting this closure, a substance appears to be thrown out anteriorly, which, by reason of its acting as the medium for closing the case and connecting this with the contained body, Dr. Stein designates the 'binding-substance.' This substance appears in the form of plaits or folds crossing each other (P. 22, f. 12, 13.) The animal is now seen as a motionless granular mass, not entirely filling its case, without trace of its mouth and frontal wreath, but still possessing a contractile vesicle, or a nucleus, or both. From between each of the angles of the binding substance, filiform fibres proceed, with rounded knobs at their apices, flexible, and capable of elongation or retraction. These fibres, Stein believes, are of the same nature as the variable processes of *Amœba* and *Arcellina;* they move freely about, crossing one another, and often entangling small Infusoria, or other floating particles, which they draw towards the surface of the Acineta. However, neither such captured particles, nor any others, are ever seen to enter within the cyst; nor are any food globules to be detected within the body; for there is no mouth, all communication with the exterior being cut off by the outer tough case or integument, and also by the subjacent binding-substance. It

may be that nutriment is derived from the substances caught by the fibres, by means of absorbing powers resident in the bulbous extremities of the latter.

The beings of the form now described resemble the *Acineta mystacina* (Ehr.) In this *Acineta*, Ehrenberg designated the outer sheath, a lorica; the diverging fibres, the tentacles; the contained globules, stomachs; the nucleus, a testes; and the fine granules, ova; whilst he also supposed the existence of a mouth at the anterior extremity.

In different examples the length of the pedicle varies much. In some cases, the enclosing case was nearly filled by the granular body; in such, the diverging fibres were few and small, the contained granules and globules large, whilst the nucleus was indistinct or invisible (P. 22, f. 11.) These forms are an early condition of the *Acineta*, which is destined to undergo progressive changes, chiefly observable in the growing diminution in volume of the granular animal mass, which proceeds until diverging fibres, nucleus, and contractile vesicle, are no longer to be traced in the mere speck remaining (P. 22, figs. 13, 14, 15.)

As in *Epistylis*, so in *Vaginicola*, the Acineta-body developes a discoid, ciliated embryo, but there is no contraction of the outer case (sheath) as happens in the former.

Vaginicola *crystallina* (*Vorticella stentorea et Trichoda ingenita*, M.)—Lorica crystalline, straight, pitcher-shaped, slightly contracted near the open end; ova green. Found upon Lemna, &c. Length of lorica 1-210th (P. 22, f. 19, 24.)

V. *tincta.*—Lorica brownish-yellow, urceolate, and nearly cylindrical; body hyaline. Found upon Zygnema decimum. Size of lorica 1-280th.

V. *decumbens.*—Lorica brownish-yellow, oval and compressed, as shown in the engraving, group 256. The lorica is decumbent, the body hyaline. Lives with the preceding. Length of lorica 1-280th.

V. *vaginata.*—Under the name *Vorticella vaginata*, Müller has described a *Vaginicola* found in the Baltic, having a delicate pedicle as long as the body, and inserted at the upper end of a sheath six times longer than itself, into the orifice of which the body can with difficulty enter.

VAGINICOLA *Ampulla*.—Müller described this as larger than most animalcules dwelling in a bottle-shaped sheath, very contractile, grey, and soft, and occupying various positions within the case. Found in the Baltic, and, by Mr. Brightwell, at Lowestoff.

V. *ovata* (Duj.)—Body of a lengthened ovoid figure, placed in an urceolate case. Length of body 1-1000th, of case 1-550th. Apparently distinct from V. *crystallina*. Found on Zygnema in pond water.

V. ———— ? (Brightwell). — Body double, of a green colour. Probably undescribed. Found on duck weed and other small aquatic plants. It is doubtful whether this being is other than a *Vaginicola* in process of spontaneous fission.

Genus COTHURNIA. *The stilt little bell Animalcules* possess divisbility of the body, but not of the lorica, which is urceolate in shape, and supported on a rigid pedicle. A wreath of cilia is placed upon the flat frontal region; and the mouth, joined with the anal opening, lies sideway within it. The body is elastic, and can withdraw itself within the stiff lorica; polygastric apparatus and longitudinal self-division have been observed in two species. The sexual structures are not satisfactorily seen.

C. *imberbis* (*Vorticella folliculata*, M.)—Pedicle much shorter than the lorica, the body of a yellowish colour. Ehrenberg remarks, "This animalcule had often swallowed green Monads, and yet accepted indigo. *Trichodina vorax* is the enemy of this species." Found upon Cyclops quadricornis. (*Mic. Cab.*, plate viii. group 257.) Length of lorica 1-280th.

C. *maritima*.—Pedicle much shorter than the hyaline lorica; body hyaline and whitish. Length of lorica 1-570th.

C. *Havniensis*.—Pedicle much longer than the hyaline lorica; body whitish. Size, without the stalk, 1-280th

FAMILY.—ENCHELIA.

We now arrive at Infusoria which possess a much higher organization than those hitherto described, having a distinct alimentary canal, with a mouth and discharging opening at opposite extremities of the body. These animalcules are destitute of lorica; organs of

locomotion have been observed in all the genera, and in all the species except two, but in no case do they consist of simple vibrating proboscides, but generally of numerous vibratile cilia. In the genera *Actinophrys, Trichodiscus,* and *Podophrya,* locomotion is performed by slow-moving feelers. In seven genera the organs of nutrition have been satisfactorily demonstrated, by the employment of coloured food, but only in one has the entire course of an alimentary canal been traced, though in most its course is indicated by the discharge at the end of the body. Ehrenberg states the polygastric structure is to be seen in all except the Arabian *Disoma.* A double condition as regards the sexual apparatus, is seen in *Enchelys, Leucophrys,* and *Prorodon.* Complete self-division, both longitudinal and transverse has been observed; but neither gemmæ or polypi clusters. The members of this family appear to me to resemble each other less than any membranous one that has preceded. The most curious animalcules among them are the double-bodied *Disoma* and the teeth-bearing *Prorodon.*

The genera are distributed as follows :—

- Teeth absent.
  - surface of body destitute of vibratile cilia
    - direct truncated mouth (no lip)
      - vibratile cilia at the mouth
        - body simple ....Enchelys.
        - body double ....Disoma.
      - ray-like tentacula not vibratile
        - stalkless
          - the body covered with rays ... Actinophrys.
          - rays at the edge ...Trichodiscus.
        - stalked ....Podophrya.
    - oblique truncated mouth (with lip)
      - no neck ....Trichoda.
      - with neck ....Lacrymaria.
  - surface of body with vibratile cilia.
    - oblique truncated mouth, with lip ....Leucophrys.
    - direct truncated mouth, no lip ....Holophrya.
- Teeth present ....Prorodon.

In the arrangement of Dujardin, and under his fourth order comprehending "ciliated Infusoria without a contractile integument, and with or without a mouth"—A family having the same name

Enchelia (Enchelyens) and named after a genus *Enchelys*, is instituted. But most unfortunately for science, this family and this genus, in the animalcules they include, in no way correspond with the similarly named family and genus of Ehrenberg. This is remarked by Dujardin himself, and he adds, with reference to the genus *Enchelys*, that, in the whole course of his observations, he has never met with any Infusoria bearing the characters attributed by Ehrenberg to that genus, and he is led to conclude that the beings described by that observer are *Paramacia*, with a terminal mouth, or else *Bursaria* imperfectly examined, and the cilia of the surface overlooked.

Moreover, the family *Cyclidina* (Ehr.) seems much more nearly allied to the *Enchelys* of Dujardin, but its characters, as given by Ehrenberg, are not sufficiently definite to attempt an identification. Dujardin defines his genus *Enchelys* as having a cylindrical, oblong, or ovoid body, covered with erect uniform cilia, irregularly disposed.

Genus Enchelys. *The cylinder Animalcules.*—Body single, no vibratile cilia upon its surface; mouth truncated (direct, not oblique), devoid of teeth. A wreath of cilia is distinctly to be observed around the mouth in three species; in one it is indistinct. In E. *pupa* the form of the alimentary canal is accurately seen; the polygastric cells, mouth, and discharging orifice, are recognized in all. In E. *pupa* and *nebulosa*, very delicate ova granules are observable, and in E. *farcimen* a contractile bladder. Self-division is transverse and complete.

E. *pupa* (M.)—Body turgid, club-shaped, attenuated anteriorly. The granular ova are of a pale yellowish-green colour, and disposed around the stomach cells; neither glands nor contractile bladder are visible. Figs. 258 and 259 represent two specimens: in the first the currents produced by the cilia around the mouth are distinct; they are both represented as fed on coloured substances. It is remarkable that this is the only species of Polygastrica of which Dr. Ehrenberg has figured, in his large work, the form of the nutritive system separately. Common in stagnant bog water. Length 1-140th.

E. *farcimen* (E. *farcimen et Vibrio intestinum*, M.)—Is smaller, more cylindrical and slender than the preceding; the ova are whitish. These creatures prey on other animalcules nearly as large as them-

selves, which they devour entire; this will account for the variety of forms which they assume, and require an observer to be very watchful and cautious before he can pronounce on the identity of a species. Dr. Ehrenberg, by patient observation, saw one individual undergo a great variety of forms when it had swallowed a young *Kolpoda cucullus.* To illustrate this, fig. 260 shews a young specimen with open mouth, about to devour an animalcule; this it accomplishes by the motion of the fringe of cilia producing a current in the water; the prey by this means is brought into contact with the mouth, which gradually dilates till the animalcule is entirely inclosed. During this operation it swims about, and a casual observer would imagine the form shewn at fig. 261 as the normal shape of another animalcule, while, in fact, it is occasioned by its food; as the digestion proceeds the lower part dilates, and the anterior contracts into its former shape; the animalcule then assumes an egg shape (fig. 262 to 265); and finally returns to its true form. Found in stagnant water. Length 1-430th.

ENCHELYS *infuscata.* — Body oval or spherical, and whitish; mouth encircled by a brownish ring, and not prominent. When fed with indigo numerous digestive cells become filled. Found in bog water. Size 1-280th. to 1-240th.

E *nebulosa* (M.)—Body ovate, hyaline, with a projecting mouth. This species receives carmine and indigo very readily. Ehrenberg has counted as many as nineteen digestive cells. Filled with the coloured food. Size 1-230th. to 1-570th.

Genus DISOMA (?) *The double-bodied Animalcules.*—This curious genus is characterized by a double body, destitute of cilia; that part at which the mouth is situated is truncated (direct.) The mouth is ciliated, but devoid of teeth. Within the bodies numerous little vesicular cells (stomachs) are observed, and the discharge of excrement may be seen to take place at the posterior extremity of each body.

D. *vacillans.*—Consists of two corpuscles, filiform, and slenderly club-shaped; hyaline and attenuated at the anterior extremity. Ehrenberg remarks, "Both bodies frequently swam parallel beside each other, so that they turned on their long axis and moved onwards quickly, though vacillating; sometimes both bodies gaped widely

apart from each other, but never so widely as to form a straight line. (See fig. 265.*) Found on Mount Sinai. Size 1-380th.

Genus ACTINOPHRYS. *The sun Animalcules.*—Enchelian Infusoria, of a globular shape, covered with setaceous tentacula, but without vibratile cilia. The part at which the mouth is situated is truncated (direct.) The progress of the discovery of the organization of this genus is as follows:—In 1773 the mouth was indistinctly observed; in 1783 both the mouth and reception of coloured food were distinctly seen by Eickhorn; in 1777 Eickhorn noticed the erection and depression of the tentacles or rays, and locomotion produced thereby; in 1830 Ehrenberg saw the polygastric structure, and the discharging orifice opposite to the mouth; also a short proboscis in A. *sol.* Granular matter, probably representing ova, is seen in all the species. Müller saw a round gland, and Eickhorn self-division.

Dujardin has a genus *Actinophrys* which agrees in the main with that of Ehrenberg, but occupies a much lower place in his system, its affinities being rather with the *Amœbæ* than with animalcules of so high an organization as the *Enchelia* described by Ehrenberg. The following are the characters of the family *Actinophryens*, including *Actinophrys*, *Acineta*, and *Dendrosoma*. "Animals without appreciable organization, motionless or fixed, provided with variable expansions, very slowly contractile, always simple, and the extremities of which, in contracting, often become globular"—and it is added:—

"The *Actinophryens*, whose organization seems as simple as that of the *Amœbeæ* and *Rhizopoda*, are distinguished from these animals by the extreme slowness with which they extend or retract their expansions. This slowness is such that one would many times doubt their animality, were it not that by agitation of the liquid, or by the contact of other bodies, the soft, glutinous consistence of their bodies can be detected," and the variation, the retraction or elongation of their expansions, witnessed. In the interior, granules of various sizes and vacuolæ, often very large, are to be seen. The thicker prolongations are called by Ehrenberg proboscides (trunks.)"

Kölliker has of late investigated the organization of *Actinophrys*

(Zeitschift f. Wissenschaft, Zoologie von V. Siebold, and Kölliker, 1849.) He does not admit the existence of a mouth, but supposes particles of food to enter the body at any part, by means of the pressure exerted by them on its integuments, through the agency chiefly of the radiating fibres compressing them. Dr. Stein, on the contrary, asserts that no foreign matters are ever found within the interior of *Actinophrys*. *Actinophrys* is closely allied to *Acineta;* some of the forms of the latter found by Dr. Stein, are scarcely distinguishable from the former; like which, too, they possess a nucleus and contractile vesicle.

Dujardin further remarks, "Ehrenberg has placed the *Actinophryens,* although wanting cilia, among the *Enchelia,* all of which are furnished with those organs, and he attributes to them a mouth, digestive canal, and anus, notwithstanding his having failed to feed them on coloured substances. His grounds for such disposition of these animals, are, that by their processes (tentacula) they affix themselves to other beings, which, by contact with their surface, they seem to absorb. At the same time he inserts the *Acineta* at the end of the family *Bacillaria,* and as an appended genus. However, during the printing of his work, he discovered the allied genus *Dendrosoma,* and was then led to the belief that *Podophrya, Actinophrys,* and *Acineta,* should be combined with that new genus in a distinct family, which he proposed to name *Acinetina.*" This, save in the definition, would nearly correspond to the *Actinophryens* of Dujardin. The *Actinophryens* are found both in fresh and salt water, among Algæ and Confervæ, but not in artificial infusions.

Actinophrys *sol* (*Trichoda sol,* M.)—Body of a whitish colour, of a flat pancake form; the rays diverge from every part of its body, and in length about equal the diameter of the body. Ehrenberg says, "The rays or tentacles serve to feel, to move, and to catch." Meyen states he has seen the rays, or tentacles, when cut off, twist themselves, but Ehrenberg considers that eminent botanist to have mistaken *Vibrio bacillus* for them, which is mostly present with this species. The mouth is large and round, and has a proboscis. Eickhorn appears to have seen much larger forms, which could be seen with the naked eye, and found within them whole (!) forms of small

Entomostraca! Found in the dust-like matter upon the surface of infusions; among Confervæ and other plants in soft water. Size 1-1200th to 1-430th.

Brightwell gives the following account of the tentacula and the reproduction of *Actinophrys Sol.* There tentacula appear to have the property of attaching to themselves any Infusoria which touches them; when this is the case, they contract, and the entangled Infusorium is absorbed into the body of the animal by its surface, or by the thicker expansions of its body. They multiply by division, so that two, and sometimes three, individnals are seen adhering together, by their outer edge—the middle one—the parent being the largest. They differ much in size, and are not unfrequently large enough to be seen by the naked eye. (Fauna Infusoria, Norfolk.)

The apparent property of the tentacula of *Actinophrys*, like that of the tentacules of *Actiniæ* and *Medusæ*, to attach to themselves Infusoria, which come within their reach, and to thereby kill them previously to absorption in their own substances, is mentioned also by Dujardin.

ACTINOPHRYS *viridis.*—Body spherical, greenish, rays numerous and shorter than the diameter of the body, as shewn in fig. 266. Found amongst Conferva. Diameter of the body, exclusive of rays, 1-620th to 1-280th.

A. *difformis.*—Body irregularly lobed, depressed and hyaline; rays variable in length, some longer than the diameter of the body. Diameter without rays, 1-570th to 1-280th.

A. *Eichornii.*—Body large, white, globose, rays shorter than the diameter of the body; conical. Size 1-100th. Berlin.

Dujardin gives the following species, in addition to those described by Ehrenberg :—

A. *marina.*—Differs from A. *Sol*, only in its habitat, and in the more marked contractility of its rays. Found amongst microscopic marine Algæ in the Mediterranean, and probably but a variety of A. *Sol.*

A. *digitata.*—Body depressed, rays flexible, thickened at the base, and forming, by contraction, short, thick, finger-like processes. Diameter 1-750th. Found in fresh water containing marsh plants.

Its discoid body would rather place it in the *Trichodiscus* of Ehrenberg.

ACTINOPHRYS *granata* (*Trichoda granata*, M.) — Body globular, opaque at its centre, surrounded by rays of less length than its own diameter.

Genus TRICHODISCUS. *The rayed-disc Animalcules.* — Body depressed, with a single marginal row of setaceous tentacles; vibratile cilia, and teeth absent; no pedicle; mouth truncated (direct.)

These Infusoria, by their flat disciform shape, resemble the genus *Arcella*, but, unlike the latter, are soft and shell-less, with stiff bristle-like rays. A central opening, and a large lateral gland, have been recorded by Ehrenberg, who likewise states that he has seen, though indistinctly, numerous digestive cells, but neither the reception of coloured food, nor the anal orifice.

T. *sol.* (*Actinophrys Discus*, D.) Figs. 267 and 268.—Body depressed, almost flat, hyaline or yellowish, with variable rays. The motion of this species is very sluggish; it often remains for a long time inert. Found amongst Conferva. Diameter, without rays, 1-430th to 1-210th.

Genus PODOPHRYA. *The pedicled and rayed Animalcules.*—*Enchelia*, devoid of vibrating cilia and teeth; their bodies are spherical, and covered with setaceous tentacles; mouth truncated (direct.) In organization they are similar to *Actinophrys*, with a stiff stalk.

P. *fixa* (*Trichoda fixa*, M.—*Actinophrys pedicellata*, D.)—Has a spherical, turbid, whitish body, with a diaphanous pedicle, slightly excised at the extremity. The rays or setæ have their extremities capitate, and equal the diameter of the body in length, as represented at figs. 269, 270: the latter exhibits it with two animalcules it has seized. Ehrenberg states, the seizing or catching power of this animalcule is very interesting to observe. So soon as a quickly vibrating *Trichodina grandinella* approaches to and comes in contact with, its tentacula, it is immediately taken prisoner, ceases to vibrate, and stretches out its cilia backwards. On the whole, this species resembles *Acineta*, from which it is separated by Dr. Ehrenberg, who supposes it to possess a discharging orifice, though its situation is unknown. Found among dust-like matter upon the surface of pond

water, and perhaps, says Dr. Ehrenberg, in the sea (Copenhagen.) Diameter 1-430th.

Genus ACINETA.—*The rayed little tree Animalcules.*—This genus was placed by Ehrenberg, in his great work in 1838, as an appended tribe to the *Bacillaria*, with which, indeed, its affinities were very slight, and hypothetical. In a communication since made, upon the discovery of the genus *Dendrosoma*, Ehrenberg stated, that *Acineta*, and the new genus, are allied to *Actinophrys*, and proposed to include all those three genera with the intimately associated ones, *Trichodiscus* and *Podophrya*, in a new family, to be called *Acinetina*, ranging itself between *Bacillaria* and *Vorticellina*. In accordance with these views, the genus *Acineta* is transferred from its former place to the present.

The genus *Acineta* is especially characterized by having a membranous lorica, a simple pedicle, and numerous retractile, non-vibrating tentacula.

In A. *Lyngbyei*, and A. *mystacina*, Ehrenberg describes stomach-cells; and in A. *tuberosa* and A. *mystacina*, a seminal gland. Self-division not observed.

The recent elaborate researches of Dr. Stein, have rendered the existence of *Acineta*, as an independent genus and organism, exceedingly doubtful; and go to show, on the other hand, that *Acineta* is but a transitional stage of development of *Vorticella*, *Vaginicola*, and *Epistylis*. (See the account of these genera, and P. 22.)

A. *Lynybyei.*—Lorica spherical, pedicle thick. It resembles a stalked *Actinophrys*, while the circular, radiating, pale yellow coloured body, with its thick crystalline stalk, is similar to a retracted Vorticella. Found on Polypes, as Sertularia. Length, including stalk, 1-100th to 1-170th.

A. *tuberosa* (*Vorticella tuberosa*, M.)—Lorica triangular, compressed; dilated and truncate anteriorly, with three obtuse tubercles or horns, of which the two lateral are more constant, and furnished with tentacula. Pedicle simple and slender. Size 1-210th to 1-100th. Found in marsh and sea-water, on Ceramium diaphanum. (P. 21, f. 3, 4.)

A. *mystacina* (*Vorticella*, Schrank.)—Subglobose, obtusely horned,

with two elongated bundles of tentacula; pedicle slender, fig. 205. Found upon Lemna minor. Length of entire body 1-860th to 1-120th.

Acineta *ferrum equinum.*—Body ovate, white, tentacula disposed at its front; pedicle small, thick; a central gland of a horse-shoe shape. Size 1-240th. Berlin.

A. (?) — Brightwell describes an animalcule with an oval sheath, of a dark colour, opaque and granulated, and having a bundle of diverging rays proceeding from each extremity, many of which, by contraction or otherwise, have a globular tip. They were not observed to move or catch other animalcules. Found in fresh-water at Oulton, Norfolk.

Genus Dendrosoma.—This includes beings which resemble *Actinophrys*, supported on a branching pedicle. The base of the thick pedicle or trunk is fixed, and its divisions bear at their extremities the animalcules. In appearance, therefore, it resembles a microscopical Sertularian polype.

D. *radians.* — Corpuscles (animacules) conical, dense; on soft, smooth, and alternately disposed branches; and furnished with tentacula.

Genus Alderia.—Mr. Alder has described and figured (Ann. Nat. Hist. vol. vii, 1851, p. 427) three new species of Infusoria, which he esteems to be most akin to *Acineta.* Unfortunately for any systematic arrangement, he has contrived no names for them; if we might be allowed, we would suggest the generic appellation Alderia, in honour of the discoverer.

The following characteristics are condensed from Mr. Alder's account, and, for convenience sake, we have ventured upon specific or trivial names, for the three species indicated.

A. *apiculosa.*—Body vase—or cup—form, expanded at the top, and set round with numerous pointed tentacles, abruptly thickened towards the base, and forming more than one row; they had very little motion, but were occasionally bent forwards, and the whole were sometimes slowly retracted. The body was attached by a tolerably stout stem. Found parasitic on Sertularia.

A. *ovata.*—Body ovate, with a very slender and short stem; ten-

tacles capitate or knobbed at the end, not so numerous as in the first species, and placed in a single row round a narrow disc. Parasitic on Sertularia.

ALDERIA *pyriformis.*—Body pear-shaped, or perhaps rather bell-shaped, with a distinct rim round the top, and a single circle of delicate capitate feelers (tentacula), which, as in the former instance, were retractile. Stem long and slender. Parasitic on Paludicella, and, unlike the preceding, inhabiting fresh water.

Mr. Alder's first impression, regarding these creatures, was, that they were new forms of Campanularian Zoophytes (*i. e.*, of Polypes.) A more careful examination, however, convinced him that their organization was much more simple than is to be found in the true Polypes, and that they must be considered to belong to the class Infusoria. Their relation to the *Vorticellæ* is remote, and they come nearest to *Acineta.* The *Acineta mystacina* (Eh.) somewhat resembles the last species, but its form appears much more simple, and the tentacles rise irregularly from different parts of the body. These animalcules are of interest, as forming a more perfect link between the Infusoria and the Campanularian Zoophytes, than any hitherto known. We ourselves feel more disposed to range this genus in the family *Vorticellina,* than with *Acineta.*

Genus TRICHODA. *The hair Animalcules.*—Body (?) devoid of hairs or cilia; mouth truncated (oblique), destitute of teeth, but provided with vibratile cilia, and a lip, but no neck. The polygastric apparatus is satisfactorily proved by the employment of coloured food, and the posterior anal spot is also known. The oblique direction of the mouth gives rise to a very characteristic upper lip-like projection. In T. *pyrum* only has self-division been observed. All the species are colourless.

T. *pura* (*Kolpoda pyrum,* M. figs. 271, 272, 273.)—Body oblong, club-shaped, with small vesicles. The anterior part attenuated, and the mouth lateral. Common in vegetable infusions; usually with *Cyclidium glaucoma.* Size 1-720th.

T. *Nasamonum.*—Body cylindrical, extremities equally obtuse, mouth large, and elongated laterally. Size 1-288th.

T. *ovata.*—Body ovate, turgid, attenuated anteriorly; mouth small and lateral. Size 1-480th

Trichoda (?) *Æthiopica.*—Body oblong, attenuated posteriorly; under side flat; mouth large. Size 1-600th.

T. *Asiatica.*—Body oval, oblong, cylindrical, rounded at both ends; mouth small. Size 1-860th.

T. *pyrum* (*Kolpoda pyrum*, M.)—Body ovate, turgid, acute anteriorly. Found amongst Conferva and in infusion of celery. Size 1-1200th.

In the system of Dujardin there is both a family *Trichodiens*, and a genus *Trichoda*. Speaking of the relations between them and the genus *Trichoda* of Ehrenberg, he observes: "M. Ehrenberg has placed in his family *Enchelia*, a genus *Trichoda*, which in part corresponds with ours; and he has, besides, dispersed among *Leucophrys*, *Enchelys*, *Trachelius*, *Loxodes*, &c., many Infusoria which we have brought together in this family (viz., *Trichodiens*), since we, unlike him, are unable to see their digestive organs."

The *Trichodiens* are soft, variable, flexible animalcules, ciliated, and either with an evident mouth, or one indicated by a varying arrangement of longer cilia. Dujardin would have it understood, that this family is only provisional; to comprise a tribe of animals intermediate in organization between the *Enchylens*—the most simple of ciliated—and the *Keroniens*, which conduct to the highest forms of infusorial life, having defined mouths, and an armature of styles, hooks, &c. The genera included by Dujardin in this family—*Trichodiens*, are, *Trichoda*, *Trachelius*, *Acineria*, *Pelecida*, and *Dileptus*; the two last having a higher grade of organization.

Trichoda (Duj.)—Body ovoid-oblong, or pyriform, rather flexible anteriorly, with a row of cilia directed backwards, and appearing to indicate the presence of a mouth. Their surface does not appear reticulated, or ciliated in rows, as it is in *Acomia* and *Enchelys*. The *Trichoda* are chiefly found in Infusions and in stale marsh water.

T. *angulata.*—Body oblong, obliquely and regularly plaited or angular, often with one or more superficial vacuolæ. Size 1-900th.

T. *Pyrum* (*Kolpoda Pyrum* ? M.)—Probably *Trichoda Carnium.*

Genus Lacrymaria. *The tear Animalcules.*—Body with a long narrow neck, slightly enlarged near the termination, where the ciliated and lateral (lipped) mouth, destitute of teeth, is situated

Body not ciliated. Locomotion is performed by means of the neck, the distensible body, and the oral cilia. The proboscis-like lip is very short, sometimes distinctly articulated, and projects but little beyond the oral orifice. The polygastric structure can be demonstrated by employing coloured food, and its discharge at the end recognized in one species; in another, green (ova) granules are present.

The genus *Lacrymaria* of Dujardin, agrees mainly with that of Ehrenberg, but is ranged with the 'Parameciens.' The French author differs entirely from Ehrenberg, in the statement that the *Lacrymaria* are distinctly ciliated on their surface, that the cilia are disposed in regular series among the reticulations of the integument; and he also affirms that the mouth is not visible, but only presumed from the appearance and arrangement of the larger cilia near the extremity of the neck; and he mentions the variability of their form, as remarked by Baker, and other old observers; whence the appellation *Proteus,* originally given them.

The *Lacrymaria,* of Dujardin, are distributed by Ehrenberg among the *Lacrymaria,* the *Phialina,* and in the genus *Trachelocerca.*

LACRYMARIA *proteus* (*Trichoda proteus,* M.)—Body oblong, turgid, with delicate transverse folds. The neck is capable of considerable extension (see engraving P. 6, f. 274, 275; in the former it is extended, in the latter contracted.) It resembles *Trachelocerca olor,* but its posterior extremity is rounded, and has at its centre the discharging orifice. Reproductive organs unknown. Found amongst Lemna. Size stretched out, 1-140th.

L. *gutta.*—Has a smooth and nearly spherical body, with a very long neck. Found with Conferva. Size 1-1150th; including neck, 1-210th.

L. *rugosa.*—The body of this animalcule is nearly globular, and wrinkled; the neck is of a medium length, and the ova green. In swimming it often revolves on its longitudinal axis; neither cilia nor an enlargement is observable near the mouth. Size 1-570th; including neck, 1-288th.

The additional species given by Dujardin are:—*Lacrymaria versatilis* (*Trichoda versatilis,* M.)—Fusiform; neck retractile; ciliated beneath its extremity; neck shorter than in L. *proteus;* and, unlike it, pointed posteriorly, and lives in sea-water.

Lacrymaria *tornatilis*.—Neck retractile, sometimes disappearing entirely, presenting then only the cilia crowning its extremity.

L. *farcta*.—Flask-shaped, with a short neck. Found in ditch-water about Paris. Length 1-260th.

Genus Leucophrys.—Body with vibratile cilia, covering its whole surface; mouth obliquely terminal, without teeth. From the obliquity of the mouth the upper part appears like a lip. The cilia which cover the body, are short and disposed in rows; those around the mouth are longer, and produce very powerful currents. In swimming all the species revolve upon the longer axis. A serpentine alimentary canal (with numerous grape-like stomach-cells, more than fifty), terminating at the opposite extremity to the mouth, is present. In three species, numerous ova granules are observed, and in some, one or two globular glands and simple contractile bladders. Transverse and longitudinal self-division have been observed.

Leucophrys forms, in the system of Dujardin, with *Spathidium* and *Opalina*, the family '*Leucophryens;*' characterized by having an oval or oblong depressed body, covered with cilia densely, but regularly disposed. They have no evident mouth; if one be present, it can only imbibe fluid, for foreign solid particles are not to be found in their vacuolæ; hence they probably live only by absorption. Most of them are parasitic in Annelida and Batrachia, and soon perish in pure water, like Helminthoid (tape) worms. In *Opalina*, an anterior oblique cleft probably indicates a mouth. Dujardin says—"It is to the genus *Bursaria* that Ehrenberg has transferred most of the true '*Leucophryens*,' in conjunction with other Infusoria having a very distinct mouth."

Dujardin's characters of *Leucophrys* are:—Body depressed, oval, or oblong, equally rounded at the two ends, covered by long, very numerous, vibratile cilia, in parallel rows; no mouth—"I have restricted the term to animalcules parasitic in *Lumbrici;* but should probably include the form met with by Ehrenberg in the *Anodonte*."

L. *patula* (*Trichoda patula*, M.—*Bursaria patula*, Duj.)—Body oval, campanulate, turgid, as shewn in fig. 276, 277. It is sometimes quite pellucid, at others of a whitish colour; mouth ample and gaping; the stomach-cells are very large, and fill themselves in an irregular manner. When the animalcule is quiet, the passage of the

food onwards is seen in the serpentine canal, to which the stomachs are attached like berries; even, says Dr. Ehrenberg, the stalk or short tube connecting them is visible when they receive or discharge coloured food. The longitudinal rows of cilia are very numerous in full-grown specimens. The ova are white by incident light, brownish by transmitted. In the middle of the body is a small globular male gland. Found both in fresh and sea-water. Size 1-280th to 1-96th.

Leucophrys *Spathula* =Enchelys *Spathula,* M.)—Body lanceolate, compressed, whitish, membrane-like at its anterior extremity, where it is obliquely truncated, and a narrow mouth situated. Found amongst Lemna. Length 1-140th.

L. *sanguinea* (*Trichoda striata,* M) fig. 279.—Body cylindrical, rounded at both extremities, and of the colour of blood. Ehrenberg remarks that within it are two bright contractile round bladders, and that when the creature undergoes self-division, (fig. 280), there is always one in each part. Length 1-144th; ova granules 1-12000th.

L. *pyriformis* (*Kolpoda pyrum,* M.)— Body ovate, whitish, rather more acute anteriorly; ventricles large. Size 1-570th to 1-280th.

L. *carnium* (*Kolpoda pyrum,* M.) — Body oval, oblong, acute anteriorly, and of a whitish colour; ventricles narrow. Found in putrescent animal water, and draining of manure. Size 1-1440th to 1-430th.

L. (?) *anodontæ* (*Leucophra flinda,* M.)—Body oval, turgid, and transparent; rounded at both extremities. Found in Siberia and Copenhagen. Size 1-430th

L. *striata* (Duj.)—Body oblong, marked by thirty-five longitudinal granular striæ. Length 1-325th to 1-200th. Found in Lumbrici (worms) of gardens.

L. *nodulata* (Duj.)—Body oblong, regularly ciliated; without distinct striæ; but having two series of vacuolæ. Found also in Lumbrici.

The two other genera of Dujardin's family '*Leucophryens,*' are *Spathidium* and *Opalina:* the latter we shall speak of under the genus *Bursaria,* in which some of its examples are included by Ehrenberg.

Genus Spathidium. — Body oblong, thicker and more rounded behind; thinner, expanded, and truncated in front.

S. *hyalinum.*—Body oblong, lanceolate, hyaline; thin, and almost

membranous anteriorly, and terminated by an oblique margin; along which some small black nodules may be seen. In pond-water, near Paris. The *Enchelys Spathula*, of Müller, would seem to be the same species; but the *Leucophrys Spathula*, of Ehrenberg, differs from it in having a row of cilia on the anterior margin, with striæ on each side; as also in receiving indigo in its stomach-sacs. (P. 21, f. 27.)

Genus HOLOPHRYA.—*The wooly Animalcules* comprehend Enchelia covered with vibratile cilia; body ovoid, oblong, or even cylindrical; mouth anterior, directly truncated or terminal, and without lip or teeth. Digestive cells have been seen in all the species; and in two, the mouth and discharging orifice. The cilia are disposed in longitudinal rows. In H. *ovum* green granules and a posterior contractile bladder are observable; self-division appears to be transverse in H. *discolor.*

H. *ovum* (*Leucophra bursata,* M.)—Body ovate, somewhat cylindrical, extremities sub-truncate (fig. 281); ova green. Found amongst Lemna and Conferva. Size 1-570th to 1-210th.

H. *discolor* (*Trichoda horrida,* M.)—Body white, ovate, conical, subacute at the posterior extremity; cilia long and scattered. Found amongst Conferva. Size 1-240th.

H. *coleps* (*Leucophra globulifera,* M.)—Body oblong, cylindrical; rounded at both extremities. It is of a white hue. Size 1-430th to 1-280th.

Holophrya, and the following genus *Prorodon,* are included in Dujardin's family, *Paramecìens.*' One new species is described, viz.:—

H. *brunnea.*—Body brown, changing from a cylinder to a globular form, when filled with food; and also then altering in colour.

Genus PRORODON. *Toothed cylinder Animalcules.*—This remarkable genus is distinguished by its directly truncated mouth, furnished with a circlet of internal teeth. The body is covered with vibratile cilia. A polygastric system of nutrition (with anterior and posterior orifices of the alimentary canal) has been observed, by feeding with colouring matter. A long band-like gland and contractile bladder, with a granulated mass, are seen in P. *niveus.*

P. *niveus.* — Body large, elliptical, and compressed; colour white; circlet of teeth compressed, as shewn separate at fig. 283.

Amongst Conferva in turf pools. Length 1-72nd; ova granules 1-2400th.

Prorodon *teres.*—Body ovate, cylindrical, (fig. 282); colour white; circlet of teeth cylindrical. Ehrenberg counted twenty teeth; when broken up, forty-five. In swimming it revolves upon the long axis of the body. Size 1-140th.

P. *viridis.*—Body large, elliptic, compressed, green, with a nearly cylindrical crown of teeth. Size 1-120th. Berlin.

Besides the new or newly-styled genera of the family *Enchelia*, we have yet to append some genera (whose affinity is with the foregoing) described by Dujardin in his family '*Enchelyens*,' called by him *Acomia Gastrochæta*, *Alyscum*, and *Uronema;* and which, with the genus Enchelys, constitute the family Enchélyens.

The *Acomia* and *Gastrochæta* are only ciliated partially, the former at one end, the latter along a longitudinal furrow on the under surface; whilst *Enchelys*, *Alyscum*, and *Uronema*, are ciliated throughout; the first having but one form of cilia; the second, cilia, together with some long, contractile, trailing filaments; and the last, cilia, with a single, straight, and long posterior filament.

The Enchelyèns are found in infusions, or in stagnant water.

Genus Acomia.—Body oval or irregular, oblong, colourless or cloudy, formed of a homogeneous, glutinous substance, containing unequally-sized granules, and ciliated at one end. No mouth.

A. *cyclidium.*—Body oval, oblong, depressed, containing large granules and some vacuolæ; dividing transversely. In external form approaches *Cyclidium* (Ehr.) Marine. Size 1-650th. (P. 21 f. 16a, b.)

A *vitrea.*—Body ovoid, in part crystalline, rendered cloudy by granules in its posterior half; anterior border ciliated; division, longitudinal. Size 1-1250th. In fetid water. (P. 21, f. 17).

A. *ovale.*—Differs from the preceding by the granules occupying the *anterior* half, and by its length, 1-868th. In fetid marsh water.

A. *ovulum.*—Body ovoid, presenting a nodular or granular portion, which seems to contract itself within the interior af a diaphanous envelope. Revolves in moving. Length 1-300th.

Its motion was that of a *Doxococcus.*

A. (?) *vorticella.*—Body ovoid, nearly globular, colourless, cloudy;

ciliated in its anterior half; cilia curved backwards. Revolves on its axis in progressing forwards. Length 1-1000th. In sea water.

Acomia (?) *costata*.—Body ovoid-oblong, narrower in front; apparently inclosed by a thick membrane, or a more consistent layer, nodular; nodules often arranged in rows, as ribs. Division transverse. Length 1-650th to 1-500th. In sea water, among Algæ.

A. *varians*.—Body oblong, cylindrical; truncated and angular in front; dilated and compressed, by turns, in different parts of its length, and, consequently, alternately constricted behind, and terminated by a pointed tail, or rounded. Revolves on its axis. Length 1-1000th to 1-450th.

Genus Gastrochæta.—Body oval, convex on one side, and hollowed by a longitudinal furrow on the other; cilia seated in the furrow, chiefly at the two ends.

G. *fissa*.—Body semi-transparent, oval, truncate in front. Length 1-408th. In the water of the Seine (P. 21, f. 18.)

Genus Alyscum. — Body ovoid-oblong, irregular, surrounded by radiating cilia, and having, besides, a lateral bundle of long retractile cilia, by means of which it leaps briskly from place to place.

The single species resembles much *Enchelys nodulosa* (*Paramecium milium*, or *Pantotrichum Enchelys*, Ehr.) from which it is distinguished by its retractile filaments.

A. *saltans*.—Body colourless, oblong, rounded at the ends, rather concave along the side, bearing the retractile filaments, with some almost invisible longitudinal furrows. Length 1-1300th to 1-1130th In infusions and in the Seine (P. 21, f. 20.)

Genus Uronema.—Body long, narrower in front, rather curved; surrounded by radiating cilia, and bearing a long straight cilium behind.

U. *marina*.—Body colourless, semi-transparent, nodular, elongated; contracted in front; slightly curved, with from four to five slightly marked longitudinal striæ. Length 1-595th. In the Mediterranean. (P. 21, f. 25.)

Family COLEPINA.

The animalcules of this small family are loricated, and possess a polygastric alimentary canal, whose orifices are placed at the opposite extremities of the body. The lorica is in the form of a small cask, composed either of minute plates, placed in a row, or of little rings, between which cilia are situated. Anteriorly the lorica is truncated, smooth, or toothed; mouth ciliated; it terminates posteriorly in from three to five little points. The digestive cells in these creatures are readily filled with coloured food, and its remains ejected posteriorly. The ova granules are coloured in *C. viridis;* in the other species colourless; complete transverse self-division has been observed in one species. A distinguishing character of Infusoria is their asymmetrical figure; but the genus *Coleps* is an exception to this general rule.

Genus Coleps. *The little box Animalcules*—This being the only genus, its characteristics are identical with those of its family.

C. *hirtus* (*Cercaria hirta,* M.)—This brisk little creature has an oval white body. Its lorica is apparently composed of small polygonal plates, and between them, both transversely and longitudinally, are rows of cilia. The tablets terminate anteriorly in nineteen pointed processes, and posteriorly in three, f. 284. The mouth is furnished with cilia. f. 285; (f. 286 is an end view of the lorica.)

In my work on Animalcules, I have stated the difficulty there was in examining it, from its restless habits; and Ehrenberg makes a similar statement, and says, in swimming it is difficult to perceive its lorica, but when dried, or pressed between glasses, the little shields composing it are rendered visible. Found amongst Conferva. Rather scarce. Length 1-570th to 1-430th.

C. *viridis.*—Body green, oval and ciliated; lorica composed of plates terminating in three points. Found amongst Conferva. Size 1-960th to 1-570th.

C. *elongatus.*—Body cylindrical, elongated; lorica tabulated, white, and terminating in three points; transverse self-division has been observed. Size 1-570th to 1-430th.

C. *amphicanthus.*—Has an ovate, shorter body; lorica composed of rings; the anterior part crowned with unequal teeth, the posterior

having three strong spines. Found in the body of *Spirostomum virens*. Size 1-280th.

C. *incurvus*.—Body oblong, nearly cylindrical, and slightly curved; lorica tabulated and terminating in five points. Found amongst Conferva. Size 1-430th.

Family TRACHELINA

This extensive family includes those animalcules which have an alimentary canal with two distinct orifices, the receiving one lateral, the discharging one terminal; but have no lorica. The bodies of all the genera, except *Phialina*, are covered with vibrating cilia, generally disposed in longitudinal rows, and these near the mouth longest. The cilia serve as organs of locomotion. *Trachelius* has no neck, but the frontal portion of the body is prolonged in the form of a long proboscis-like lip; in *Loxodes* and *Chilodon* it is like a hatchet-shaped broad lip. In *Glaucoma* there is a tremulous flap to the mouth; and in *Chilodon* and *Nassula* the teeth sometimes project before the mouth. The genera *Bursaria* and *Nassula* have a thick frontal protuberance, caused by the alimentary canal being curved anteriorly; numerous stomach-cells are observable, and their reception and discharge of coloured matter can be seen in all the genera. The teeth in *Chilodon* and *Nassula*, and the violet-coloured bile (gall) of the latter genus, are worthy of notice. In *Spirostomum* the mouth is of a spiral shape. Reproductive organs are of a double kind in all the genera. Complete transverse and longitudinal self-division is frequent, but neither the formation of gemmae nor clusters are observed.

The genera are disposed as follows:—

Teeth absent.	no tremulous mouth flap.	brow continuous with the body.	mouth simple	with a brow-like upper lip.	lip long, proboscis-like ..	Trachelius.
					lip broad, hatchet-shaped ..	Loxodes.
				brow-like prominent back		Bursaria.
			Mouth spiral			Spirostomum
		Brow discontinued in a peg-like manner				Phialina.
	Mouth having a tremulous flap					Glaucoma.
Teeth present	A brow-like prominent upper lip					Chilodon.
	A brow-like prominent back					Nassula.

Genus TRACHELIUS. *The neck Animalcules.*—Body ciliated, mouth simple, destitute of teeth, upper lip very much elongated, in the form of a proboscis. The last organ and the cilia serve for the purpose of locomotion ; in three species, however, no cilia are to be seen. The mouth is seated at the base of the proboscis in four species. In four species, also, the polygastric structure of the alimentary canal has been demonstrated by coloured food, and in three the discharging orifice; but, from the rounding off of the extremities of the others, the latter has only been presumed. In *T. meleagris* the gall is of a pale red colour. The propagating apparatus of two species is hermaphroditic; in the others it is only partially demonstrable. In *T. ovum* and *T. meleagris* the expulsion of ova granules has been seen. Two species increase by transverse self-division.

The account given by Dujardin, of the animals of this genus *Trachelius*, differs much from the foregoing. According to it, *Trachelius* is destitute of a contractile, or reticulated integument; and is composed of a glutinous substance, containing granules which are oftentimes agglomerated in the form of nodules, disposed in rows. The oviposition, Ehrenberg believed he witnessed, in *T. ovum*, and *T. meleagris*, was, according to Dujardin, nothing more than the breaking up of part of the animalcule by 'diffluence,' and the supposed ova only particles of 'sarcode.'

"The cilia at the anterior extremity are larger than those on the rest of the body. Posteriorly a large vacuole is often to be seen. There is no distinct mouth."

This genus *Trachelius* forms a member of the family '*Trichodiens*,' (Duj.) along with *Trichoda*, and genera named *Acineria*, *Pelecida*, and *Dileptus*.

T. *anas* (*Trichoda anas et index*, M.)—Body white, clavate, and cylindrical; proboscis thick, obtuse, and shorter than half the body; mouth situated close to the base of the proboscis. F. 287, 287*, exhibit two full-grown Infusoria; the former shows the current produced to bring the food within its reach; f. 288 is a specimen undergoing transverse self-division; and f. 289 a young one. Found in exposed infusions, and amongst Conferva. Size 1-280th to 1-120th.

T. *vorax*.—Body clavate, ovate, turgid, colour white; thick obtuse proboscis, shorter than half the body; mouth situated near the

middle of the body, and not at the base of the proboscis. Found amongst Conferva. Size 1-120th.

TRACHELIUS *meleagris.*—Body compressed, lanceolate, often curved in the form of the letter S; proboscis thick obtuse, shorter than half the body; it has along the back a series of vesicles, like a string of pearls. Size 1-96th to 1-72nd.

T. *lamella* (*Kolpoda lamella*, M.)—Body depressed laminated, linear-lanceolate, often truncated anteriorly, and rounded, with the margin ciliated. Size 1-900th to 1-280th. In sea-water (f. 24 a.b., Plate 21.

T. *anaticula.*—Body white, small, ovate, pyriform, attenuated and diaphanous anteriorly. Dujardin believes he has seen several of these animalcules simply agglutinated together, which if so, would indicate the absence of a true integument. Found amongst Conferva. Size 1-570th to 1-280th.

T. (?) *tricophorus* (*Vibrio strictus*, M.).—Body cylindrical changeable, often clavate; proboscis capitate, of the form of a very delicate whip. Size 1-1200th to 1-430th.

T. (?) *globulifer.*—Body spherical, hyaline, with a very delicate whip-like acute proboscis. Found amongst Conferva. Size 1-200th.

T. *ovum.* (Fig. 290).—Body ample, ovate, broadly open, or campanulate anteriorly; proboscis short, in the form of a beak; colour white. In no infusorial animalcule is the alimentary canal so easily seen as in this; the large mouth and contractile vesicle lying over the lower part of the alimentary canal, are equally evident; numerous small digestive cells and ova-granules appear in every part. Found in stagnant bog-water. Size 1-72nd.

T. (?) *laticeps.*—Body flattened, elliptical; anterior part (head) membranous, variable and wide, with a notch from which a flagelliform proboscis proceeds double almost, in length that of the body. Size 1-912th. In North Sea.

⁂ Although the names of some of the species of *Trachelius* described by Dujardin, differ from those given by Ehrenberg, yet the definitions indicate no new species.

Genus LOXODES.—*The lipped Animalcules.*—Bodies covered with cilia, mouth simple, devoid of teeth; upper lip continuous and broad, hatchet-shaped; the organs of locomotion are the rows of cilia on

the body generally and the long ones near the mouth. Coloured food has demonstrated the polygastric structure of three species, and in one has shown the point of expulsion. In *L. Bursaria* propagating apparatus of a double kind, viz., ova-granules, an oval gland, and two contractile globular vesicles, have been seen, and in two others the granules only; self-division transverse.

Dujardin's characters of *Loxodes* are,—" Body flat, membranous, or with an apparent membranous lorica, flexible but not contractile, expanded at the centre of its superior or dorsal surface; often concave on the under surface; contour irregularly oval, sinuous and obliquely prolonged anteriorly, furnished with very fine cilia confined to its anterior margin." In general characters it approaches nearest to *Trachelius* (family *Trichodiens*), but the signs of an integument are so clear as to sever it from that genus and family. The *Loxodes,* described by the French author, are almost all of them distributed by Ehrenberg among other genera and families, and hence there unfortunately is but the slightest relation between the similarly named genus of the two writers. Thus the *Loxodes rostrum* of Ehrenberg, is the representative of a genus *Pelecida,* of the family *Trichodiens* (see page 580), in the system of Dujardin, and bears the name of *Pelecida rostrum.* In this position it is brought into close relation with the genera *Trichoda* and *Trachelius,* (Ehr.) and with two others, named by Dujardin, *Acineria* and *Dileptus.*

The last mentioned genus comprises Infusoria placed by Ehrenberg with *Amphileptus,* in describing which we shall take the opportunity to give the characters of *Dileptus,* whilst *Acineria* and *Pelecida* will be included among the appended genera at the end of the present family *Trachelia.*

Loxodes *rostrum* (*Kolpoda rostrum, M. Pelecida rostrum* D.)—Body compressed, white, lanceolate, slightly curved in the form of an S, in consequence of the lip being a little uncinated. Ehrenberg states that he has very often seen large *Naviculæ* and *Synedræ* within this creature, but that it would not feed on coloured food. The cilia are very delicate. Fig. 291 represents an animalcule which has fed upon Bacillaria; fig. 292 another creeping along Conferva; and fig. 293 a specimen undergoing transverse self-division. Found amongst Conferva. Size 1-144th to 1-60th; ova granules less than 1-24000th.

Loxodes *cithara* (*Trichoda aurantia,* M.)—Body triangular and compressed; anteriorly dilated and obliquely truncated, but pointed at the posterior extremity. Colour white. Size 1-430th to 1-210th.

L. *bursaria.*—Body oblong; anteriorly, obliquely truncated and depressed; posteriorly hemispherical. Found in bogs. Size 1-280th.

L. *plicatus.* Body elliptical, depressed, convex on the back, and slightly plicated; the lip uncinate. Found on Conferva. Size 1-430th.

The species of *Loxodes* mentioned by Dujardin, are *L. cucullulus* = *Chilodon cucullus* (Ehr.); *L. cucullis* = (?) *Kolpoda cucullis* M., and seemingly placed by Ehrenberg among the *Kolpoda.*

L. *reticulatus,* having an oval body, more slender and sinuous anteriorly, as also more flexible; surface granular. In marsh water long kept.

L. *marinus.*—Body depressed, oval, almost reniform; with internal fine granules, and a row of puncta near both the anterior and posterior margins. Length 1-350th. Found in salt water.

L. *dentatus,* similar to L. *cuccullulus,* but having a bundle of bristles about the mouth, as in *Chilodon,* from which it differs by the lorica (cuirasse) and by the absence of cilia on the surface.

Genus Bursaria. *The purse Animalcules.*—This interesting genus is composed of creatures covered with cilia; anterior part convex; mouth not terminal, though simple, toothless, and devoid of tremulous flap. The cilia serve as organs of locomotion, and are distinctly seen in coloured water; they are generally disposed in rows, those around the mouth are longer than the others. The nutritive system consists of an alimentary canal, curved forwards; it is furnished with digestive cells resembling little purses, which are attached to it by short stalks. The mouth is large, situated, not as in *Leucophrys,* obliquely at the anterior extremity of the body, but laterally, so that, as it were, a brow either projects over it or else forms the end. Their bile is white or reddish, the propagative apparatus hermaphrodite in three species, and in five but partly known. Self-division, longitudinal or transverse, has been observed in five species.

M. Dujardin has the following remarks on this genus *Bursaria.* "Ehrenberg, whilst admitting a genus *Bursaria,* separates from it several true species, and places some of them in his genus *Leucophrys,*

others in his family *Kolpodea;* whilst the closely allied genera *Kondylostoma* and *Plagiotoma* are confounded with other families; the former with *Oxytricha,* the latter with *Paramecium.*

"Moreover, the obliquity of the mouth in *Bursaria* is not a sufficient distinction between that genus and *Leucophrys;* and whilst assigning a large mouth to *Bursaria,* he includes among them several species in which the existence of a mouth, to say the least, is doubtful."

Dujardin creates a family '*Bursariens,*' which he divides into five genera, viz., *Plagiotoma, Ophryoglena, Bursaria, Spirostomum,* and *Kondylostoma.*

The first new genus *Plagiotoma,* is characterized by being much flattened, or lamellar; ciliated, and parasitic, and appears correspondent with the *Paramecium compressum* of Ehrenberg. The other new genus, *Kondylostoma* has an elongated compressed form, with a large lateral mouth and marginal cilia; = *Oxytricha caudata.* Ehr.

(*a.*) *Sub-genus* BURSARIA.—*The inferior* (*not anterior*) *lip reaching to the frontal margin.*

BURSARIA *truncatella* (M.) *The truncated Bursaria.*—Body large, white, ovate, turgid, truncated, and broadly excavated in front, where is a simple row of cilia. In some specimens, Ehrenberg saw half-digested Rotiferae, and large quantities of vegetable matter in the nutritive cells, and was able to see the canal fill itself with carmine, but could not follow the whole course of it. In each cell the food is surrounded by a clear fluid, which Ehrenberg calls bile. A large bright bladder is seen below the mouth, and somewhat to the left of it, on which side is also a large curved but not articulated gland, reaching to the brow or front. They are visible to the naked eye. Found in ditches, in woods, amongst rotten beech leaves. Size 1-48th to 1-36th.

B. *vorticella.*—Body white, large, nearly spherical, and turgid; anteriorly truncated, and widely excavated, with a double row of cilia. Found with *Chlamidomonas pulvisculus* and *Gonium pectorale,* some of which are seen within it in fig. 294. Size 1-108th.

B. *vorax.*—Body large, oblong, rounded at the ends; mouth ample, being one third the length of the body, and touching the summit of the frontal region. This species has great resemblance to *Urostyla grandis* and *Stylonychia lanceolata,* when their claws and styles are

withdrawn. Found in summer in muddy water. Size 1-140th to 1-108th.

Bursaria *entozoon.*—Body large, cylindrical, turgid, nearly equally rounded at the extremities; mouth small, situated near the frontal apex. Found, with the following, in the rectum of *Rana temporaria* (the Frog), in summer and winter.

B. *intestinalis* (*Vibrio vermiculus*, M.)—Body slender, cylindrical, attenuated posteriorly; mouth small, below the frontal apex. In this species, as well as in others, Ehrenberg has seen transverse self-division. Size 1-240th to 1-120th.

B. (?) *cordiformis.*—Body reniform, front depressed, mouth slightly curved in a spiral manner; colour white. Size 1-210th.

B. *lateritia* (*Trichoda ignita*, M.) *The brick-red coloured Bursaria.* —Body compressed, ovato-triangular, with the front sharply crested. Found with Lemna, Conferva, &c. Size 1-430th to 1-144th.

(*b.*) Frontonia.—*Anterior part of the body* (*brow*) *projects beyond the mouth, and is convex.*

B. *vernalis* (*Leucophra virescens*, M.)—Body oval, turgid, rounded at the ends, and attenuated posteriorly. The mouth has a wreath of stiff short bristles, resembling teeth; numerous stomach vesicles are often filled with large Oscillatoriæ, Naviculæ, &c., and contain a reddish bile. The process of digesting the Oscillatoriæ is interesting to follow:—they are at first elastic and rigid, and of a beautiful blue green colour, then distinctly lax, flexible, and bright green, becoming afterwards yellowish-green, and falling into separate articulations, which at length turn yellow. Found amongst Oscillatoria in spring. Length 1-144th to 1-120th.

B. *leucos.*—Body oblong, cylindrical extremities nearly equi-convex, bile colourless (see f. 295). This creature has a contractile bladder, with a curious jagged margin near the long open mouth. Found with Oscillatoria, and on the surface of water. Size 1-144th.

B. *pupa.*—Body white, ovato-oblong, rather acute posteriorly; mouth aperture inferior, and near the frontal apex (see f. 296). Found in chalybeate water in Germany. Size 1-280th.

B. *flava.*—Body ovato-oblong, often acute at the posterior extremity; the mouth appears as a flat cavity immediately behind the round brow. Found in bog water. Size 1-140th to 1-96th.

BURSARIA *nucleus*.—Body small, white, ovate, attenuated anteriorly; extremities convex. Found in *Rana temporaria* and *R. esculenta.* Size 1-240th.

B. *ranarum*.—Body ovate, lenticular, and compressed, sub-acute anteriorly; the back and belly carinated, and often truncated posteriorly; mouth inferior, situated near the frontal apex. Size 1-210th to 1-72nd.

B. (?) *aurantiaca*.—Body ovato-oblong; anteriorly obtuse; posteriorly acute; it has an ash-coloured spot near the mouth. Found amongst Oscillatoria. Size 1-280th.

Genus SPIROSTOMUM. *The snail Animalcules.*—Body very elongated, flexible, and ciliated, the frontal region continuous; mouth lateral, spirally shaped, devoid of teeth, but with a tremulous flap. The cilia, which are disposed in rows, serve as organs of locomotion; those at the oblique frontal ridge are longer, and form, as in *Stentor,* a spiral wreath around the mouth; in S. *ambiguum* the brow and wreath are remarkably long. Digestive cells, to the number of ninety, have been demonstrated by coloured food, and the discharge of the latter observed. They are hermaphrodite. A band-like thick gland is seen in *S. virens*, and a bead-like one in other species; the former likewise possess a large contractile bladder, and green ova granules; but in S. *ambiguum* the latter are white. Self-division has not been observed, but Ehrenberg presumes a transverse mode exists.

S. *virens*. (*Bursaria Spirigera*, D.)—Body egg-shaped, depressed, truncated anteriorly, and rounded posteriorly. The back is arched, and the under side flat. The green ova granules are sometimes absent. (f. 296*.) Size 1-120th; ova 1-6000th.

S. *ambiguum* (*Leucophrys, Trichoda ambigua*, M.)—Body white, cylindrical, filiform, and pliant, obtuse anteriorly, and truncated posteriorly; the body extends very much beyond the mouth, forming an elongated frontal region or brow. The long vibrating cilia in front often appear like a proboscis, and were mistaken for such by Müller. The structure of this creature is remarkable, especially the mouth, which is only one-fifth from the tail; thus the front or brow is very long, and the alimentary canal, first inflected forwards, returns along the body. From the mouth to the

anterior or top of the brow runs a long ciliated furrow. Figures 297 and 298 represent this creature. In swimming they extend themselves, and are thus readily perceived by the naked eye. Found in ditches, among decaying oak leaves and rotten wood. Length 1-12th; ova 1-12000. It is visible to the naked eye.

Genus PHIALINA. *The bottle Animalcules* have the frontal ciliated portion separated from the body by a constriction, forming a sort of neck; body destitute of cilia; mouth lateral, and devoid of teeth. The motion of these creatures is produced by the vibration of the powerful wreath of cilia over the mouth. Ehrenberg says cilia may be present upon the surface of the body, as Müller saw them in *Trichoda mellitea.* The propagative organs are green or white ova granules, and a contractile bladder (perhaps two), situated posteriorly. Self-division probably transverse.

P. *vermicularis* (*Trichoda vermicularis,* M.)—Body egg-shaped, attenuated anteriorly, neck very short; colour white, caused by its ova. Found with Lemna. Size 1-240th.

P. *viridis.*—Body bottled-shaped, anterior part acute, the posterior gradually attenuated; neck very short. (f. 299.) Length 1-280th.

Genus GLAUCOMA. *The pearl Animalcules.*—Body oval, compressed, covered with cilia; mouth provided with a tremulous flap, but no teeth. The reception and discharge of food, and the presence of digestive cells, indicate, according to Ehrenberg, the existence of an alimentary canal. The large mouth, with its vibratory valve, is situated on the inferior side, near the middle. The reproductive organs are a large ovate gland, a star-like contractile bladder, and ova granules. Self-division transverse or longitudinal.

Glaucoma is comprised by Dujardin among his '*Parameciens.*'

G. *scintillans* (*Cyclidium bulla,* M.)—Body elliptical or ovate colourless, slightly depressed; ventricles large. The vibrating flap appears to be a semi-oval proboscis, with stiff margin. The cilia are seen by employing colour, or by pressing or drying them. Figures 300, 301, and 302, represent different views of this creature; the latter shows it while undergoing transverse self-division. Found both in natural and artificial infusion. Size 1-280th.

G. *viridis* (Duj.)—Body green, oval, short, mouth large, situated

nearer the centre than the anterior margin. Length 1-860th to 1-520th. Found in a rain water-butt.

Genus Chilodon. *The lateral-beaked Animalcules.*—Body irregularly oval, flattened, regularly ciliated; frontal region produced in the form of a broad membranous lip, expanded on one side, resembling a beak; the mouth, situated at its base, is furnished with a tabular fascicle of teeth. In one species a straight alimentary canal, with digestive cells attached to it, is seen; ova granules, and a contractile vesicle are visible in three species; an oval gland in all; in one only has transverse and longitudinal self-division been observed, and in this the parts separated are so small that they may be considered as gemmæ or buds.

C. *cucullus* (*Kolpoda cucullus*, M.)—Figs. 303 to 307. Body depressed, oblong, rounded at the ends; frontal region advancing on the right side. Ehrenberg states he has often seen the straight alimentary canal, with its grape-like cells, filled with large Naviculæ. Three contractile vesicles and a large oval gland near the middle have been observed. The circlet of teeth (figs. 308 and 309) consists of little hard wand-like bodies; these the creature can separate so as to admit into its mouth large living bodies, after which it contracts or closes them. (See the engravings.) In swimming, or creeping upon the surface of Conferva, the mouth is turned under or below. Its motion is gliding, and it does not revolve in swimming. When the water is coloured, the cilia may be easily perceived, and their disposition when it is dried up. Figs. 305 and 306 exhibit it while undergoing longitudinal, and 307 transverse, self-division. Found both in fresh and salt water. Size 1-1150th to 1-140th.

C. *uncinatus.*—Body depressed, oblong, rounded at the ends. The right side of the anterior part is produced, so as to appear like a hook or beak. Found in vegetable infusions. Size 1-430th.

C. *aureus.*—Body ovate, conical, turgid, of a golden yellow colour, dilated and obtusely rostrated anteriorly, attenuated posteriorly. Size 1-140th.

C. *ornatus.*—Body ovate sub-cylindrical, of a golden yellow colour, equally rounded at both ends, slightly beaked; it has a bright violet spot. Size 1-180th.

Genus NASSULA.—Body covered with cilia, ovoid or oblong, turgid and prominent in front, but without the expansion or beak on one side; mouth lateral provided with a circlet of teeth, in the form of a wheel (Nassa). Numerous polygastric cells are seen, and in two species the discharging orifice. Ehrenberg states that the existence of a new system of organs subservient to digestion becomes evident in this genus: these are of a violet colour, and probably biliary glands; one is present in *Chilodon ornatus, Bursaria vernalis, Trachelius meleagris, Amphileptus margaritifer, meleagris,* and *longicollis;* they resemble the vesicular glands around the stomachs of the Rotatoria. The propagative system is double; two species have the ova granules, and all possess a large oval or spherical gland, and one or more contractile vesicles. Only transverse self-division has been observed. They are found in stagnant water, especially where Conferva and Oscillatoria are present.

N. *elegans.*—Body cylindrical or oval, slightly attenuated in front, extremities very obtuse. It is white or greenish, spotted with violet vesicles. Digestive cells, containing Chlamidomonas, or other food, may often be observed; and from fifteen to twenty rows of cilia may be seen at one view. The animalcule swims backward and forward, turning upon its longitudinal axis. The mouth is easily perceived by the currents, when indigo is mixed with the water: it has a circlet containing twenty-six little wands or teeth, which can voluntarily diverge or converge anteriorly. When self-division ensues the large central gland divides. Figs. 310 and 311 represent this creature; the latter is a young one. Found with Lemna and Conferva. Length 1-140th to 1-120th.

N. *ornata* (N. *viridis* ? D.)—Body ovate or globular, depressed, of a brownish-green colour, variegated with numerous violet vesicles. The posterior part of the body has a small excavation. Ehrenberg says there are from six to eight groups of vesicles, forming a wide circle round the mouth; these are filled with a violet-coloured juice, which is discharged with the excrement, and appears like drops of oil, but soon mixes with and colours the water. Found amongst swimming clusters of Oscillatoria by Ehrenberg. Size to 1-96th; ova 1-4800th.

N. *aurea.*—Body ovato-oblong, nearly cylindrical, very obtuse at

the extremities. The special organs for digestive juice not distinct. Size 1-120th.

We here append those genera, named by Dujardin, having a near affinity with *Bursaria*. These are, *Plagiotoma*, *Kondylostoma*, *Opalina*, and *Panophrys*. Here too must be described the genera *Acineria* and *Pelecida* (Duj.) as allies of *Trachelius*.

With reference to the two first named genera, *Plagiotoma* and *Kondylostoma*, sufficient has been said in the remarks on *Bursaria*. The third, OPALINA, is a genus constituted by M. M. Purkinje and Valentin, and accepted by Siebold as well as by Dujardin. The species called by Ehrenberg *Bursaria ranarum*, is the *Opalina ranarum* of those other authors; or indeed this *Opalina* appears the representative of *B. ranarum*, *B. intestinalis*, *B. nucleus*, and it may be also of other *Bursariæ* of Ehrenberg, if, as some maintain, they are only varieties and not species. (Ann. N. H. v. 18, p. 441.)

The *Opalinæ* are characterized by being oval or oblong, with an oblique cleft indicating a mouth towards the anterior extremity (Duj.); though, according to Siebold, they have no mouth. "They are parasitic chiefly in Frogs and Annelida, and form but an artificial and provisional genus, for if mouthless, they belong to the *Parameciens;* if they possess a mouth, to *Leucophrys*."

OPALINA *Lumbrici*.—Body oval; depressed; narrower in front, truncated behind. Length 1-185th to 1-145th. Found in Lumbricus.

O. *naïdum*.—Body oblong, or very elongated, nearly cylindrical, marked with longitudinal and transverse striæ and with scattered vacuolæ; a fold, proceeding from the anterior extremity, extends to nearly the middle. Length 1-260th to 1-130th. Found in the Naïs (one of the Annelida) f. 28-29, pl. xxi.

Genus PANOPHRYS.—Body ciliated throughout; oval, depressed, contractile; becoming ovoid, or even globular during contraction; surface marked by straight or oblique striæ, crossing one another, and beset with corresponding rows of cilia; mouth lateral. Dujardin writes,—"Being desirous of characterizing *Bursaria* by the row of large cilia—*en moustache*, which lead to the mouth, I have thought it right to establish a new genus for certain *Bursaria* of Ehrenberg, which are devoid of this character, and whose mouth is surrounded by only ordinary cilia." Unlike the *Paramecia*, they have no ante-

rior oblique fold, and are able to contract themselves into a ball. They differ from *Holophrya* by their lateral mouth. They live either in fresh, smooth water, or in sea water among plants.

PANOPHRYS *Chrysalis.*—Body ovoid, oblong, depressed, mouth accompanied by an enlargement, and placed near the front extremity. Length 1-145th. Found in sea water (f. 33, pl. xxi).

P. *rubra* (?)—Figure reniform, covered with fine cilia, and provided with a lateral mouth near the front extremity. Length 1-370th to 1-325th. In sea water. Only provisionally named.

P. *farcta.*—Body ovoid, oblong, filled with particles swallowed, giving it a green, a reddish-yellow, or various mingled colours; mouth lateral, placed between the centre and the anterior third of the body. Length 1-145th to 1-115th. In marsh water among plants. I think it is the animalcule described under three names by Ehrenberg, viz., *Bursaria vernalis, B. leucas,* and *B. flava;* and probably the *Leucophra virescens* of Müller.

Genus ACINERIA.—Body oblong, depressed, or lanceolate, with a row of cilia extending forwards on one side, which is curved like a sabre. Distinguished from *Trachelius* by the disposition of the row of cilia and the curvature forwards. Like *Trachelius,* they seem destitute of a mouth, and in this respect they especially differ from *Pelecida.*

A. *incurvata.*—Body contractile, oblong, compressed, almost lamellar, round, or obtuse behind; contracted and curved in front; a row of cilia runs along the convex edge, and there are five or six granular stripes, and one or more variable vaculæ. Length 1-590th (f. 21 a.b. pl. xxi). In the Mediterranean. It appeared to be without a reticulated and contractile integument.

A. *acuta.*—Body diaphanous with granules dispersed in its interior, oblong, compressed; pointed at its two ends, or lanceolate with one side more convex in front and fringed with a cilia. Length 1-580th. In pond water.

Genus PELECIDA. (Duj.)—Body flexible contractile, oblong, compressed, rounded behind, curved in the form of an axe in front, ciliated throughout, and furnished with a mouth either visible or demonstrable from the various objects met with in the interior of the animal.

The animalcule assumed as the type of this genus, is the *Loxodes rostrum* of Ehrenberg. It is stated to differ from the *Parameciens* by the absence of a contractile integument.

Pelecida *rostrum.* (Duj.) = *Loxodes rostrum* (Ehr.)

Family OPHRYOCERCINA.

The animalcules of this small family have no lorica; they possess an alimentary canal, with two distinct orifices, the anal one only being terminal. Although their motion is rapid, vibratile organs are only perceived near the mouth, but their long neck assists them in swimming, and indeed is sufficient alone for that purpose. Perhaps, remarks Ehrenberg, the body is covered with delicate cilia. Ova granules are seen in all the species, and a contractile vesicle in *T. biceps*. Neither self-division nor a development in clusters has been observed.

Genus Trachelocerca. *Swan-like animalcules.*

T. *olor* (*Vibrio proteus, cygnus, et olor,* M. *Lacrymaria olor,* D.)—Body spindle-shaped; neck simple, very long and flexible, dilated and ciliated at the mouth. This creature (figs. 317, 318, 319,) creeps at the bottom of the vessel containing it, and twines itself gracefully about Conferva, or the roots of Lemna, but swims awkwardly. It elongates and contracts its neck at pleasure, and is altogether an interesting object for the microscope. Greatest length, 1-36th; length of body, 1-280th.

T. *viridis* (*Lacrymaria viridis,* D.)—Body spindle-shaped, neck simple, very mobile, long, and dilated at the mouth, which has a ciliated lip. Found amongst Lemna. Length 1-120th; contracted, 1-380th.

T. *biceps.* *The double-headed Trichelocerca.*—Body spindle-shaped, white; neck long, forked, each segment with a mouth. Length, 1-190th.

T. *sagitta* = *Vibrio sagitta,* M.—Body fusiform, white, with a very long neck; head terminal, opaque. Size 1-120th. North and Baltic Seas.

Family ASPIDISCINA.

This family is distinguished from the preceding by the presence of a lorica; alimentary canal distinct, with two orifices, the discharging one only being terminal. The lorica is a firm, very transparent, combustible little shield, somewhat resembling the shell which covers the back of a tortoise; it projects anteriorly a little before the body. Long flexible bristle-like organs attached to the abdomen, enable the animalcule to climb, while the delicate cilia near the mouth, serve as swimming and purveying organs. Numerous stomach-cells have been filled with coloured food by Ehrenberg, who has also seen the discharge of matter posteriorly. In one species of *Aspidisca*, ova and an oval gland are seen; in both a contractile vesicle. Müller observed self-division, but mistook it for copulation. They are not developed in large masses.

Genus Aspidisca. *The shield Animalcules.*

A. *lynceus.* (*Trichoda lynceus*, M.)—Lorica nearly circular, truncated at the posterior end, and formed into a hook or beak in front. This animalcule generally swims or creeps with its back underwards. The mouth has very delicate cilia; the body five or six bristles (styles) posteriorly, and from five to eight hooks anteriorly, resembling, in this respect, *Euplotes* or *Stylonychia.* A contractile vesicle near the mouth, and twenty digestive cells have been seen. When burnt upon platina no traces remain. Found amongst duck-weed and Conferva. Size 1-1000th to 1-576th.

A. *denticulata.*—Lorica nearly circular, ends rounded, left side truncated and denticulated; the back is arched, the abdomen flat, and its hooked bristles are only visible when climbing. Fig. 321, pl. vii., is an under view; and figs. 322 and 323, side views. Size 1-576th.

FAMILY.—KOLPODEA.

Animalcules furnished with an alimentary canal, the orifices of which are not at opposite extremities of the body. They have no shell or lorica; they are furnished with cilia disposed in longitudinal series, which are subservient to locomotion and purveyance. In all of them, numerous digestive cells have been demonstrated by means of coloured food, as likewise both orifices of the alimentary canal; the digestive juice (bile) is colourless. The ova are scattered and numerous; in the genus *Kolpoda* expulsion of the ova has been seen. The male generative structure is of a double kind, and complete self-division is frequent, but no formation of clusters or gemmæ is seen. A sensitive system is indicated in one genus (*Ophryoglena*) by the presence of a visual point.

The genera are disposed as follows :—

Eye absent.	Short protruding tongue—Cilia	absent on the back............	Kolpoda
		present every where	Paramecium.
	No tongue...........................	with tail and proboscis	Amphileptus.
		with tail, no proboscis	Uroleptus.
Eye present			Ophryoglena.

Genus KOLPODA. *The bosom Animalcules.*—Body ovoid, sometimes reniform, anteriorly with a little tongue-like member; under surface furnished with cilia (none on the back); no eye. Their motion is not active, the cilia being few. The mouth, posterior termination of the alimentary canal, and numerous polygastric cells, may be demonstrated in one species by coloured food. The mouth and discharging orifice are both on the ventral surface, the former having a protruding tongue-like member. The ova occur in delicate strings, forming a sort of network; their exclusion has been seen in one species; a bright contractile round vesicle is observable in two species, and in another species two vesicles or sexual bladders are present. A large round or oval gland in the centre of the body has been seen in two species. Transverse and longitudinal self-division has been noticed by several observers, and in *K. cucullus* a skin or envelope.

Dujardin, speaking of this genus in Ehrenberg's system, says, "among his *Kolpodæ* which should possess a short tongue, and be ciliated only on the ventral surface, this author includes but one species with certainty, the *K. ren.* and *K. cucullio* having formerly been referred by him to the genus *Loxodes*, in which, indeed, we still leave them. But he places among the *Paramecia*, under the appellation of *P. kolpoda*, some larger animalcules, ciliated throughout, which we regard but as more developed forms of *Kolpoda cucullus*."

Kolpoda *cucullus* (M.)—Body turgid, slightly compressed; kidney-shaped, reniform, often attenuated anteriorly. Ehrenberg states the mouth is closed by a little fleshy tongue; this is most distinctly seen in *Paramecium aurelia*. When the ova are deposited, a collapse of the body ensues, and hence a change of form. When very young they are difficult to distinguish from Monads. P. 7, fig. 324, represents the normal form of this species. Fig. 325 represents the animalcule depositing its ova in a net-like mass, and figs. 326, 327, and 328, are three young animalcules, which resemble *Trichoda pyriformis*. Common in vegetable infusions. Size 1-1800th to 1-280th.

K. (?) *ren.*—Body ovato-cylindrical, kidney-shaped, and rounded at the ends. Found in river water. Size 1-288th.

K. (?) *cucullio* (M.)—Body compressed, plane, elliptical, slightly sinuated anteriorly. Ehrenberg remarks neither cilia nor tongue-like member was observable by him: hence its generic situation is uncertain. Size 1-900th.

Genus Paramecium. *The oblong Animalcules.*—Body oblong, compressed, ciliated on all sides; mouth lateral, with a (wart-like) tongue-like process; no visual point. The cilia are disposed in longitudinal series, those near the mouth are sometimes longer than the others, and are alone subservient to locomotion, except in two doubtful species. In *P. chrysalis* the long oral cilia are remarkable. The digestive cells are numerous, amounting to more than a hundred; they are arranged in a berry-like manner along the curved alimentary canal: in five species they have been demonstrated by artificial means, in a sixth by its usual green food. The ova in two species are seen as a granular mass. In all, except one species, male

organs are visible. The curious star-like contractile vesicle in the larger species is highly interesting, when physiologically considered, as are also the little black bodies seen in *P. aurelia*. In four species complete self-division, transverse and longitudinal, has been observed alternately.

Deriving its name from this genus, M. Dujardin establishes a family '*Parameciens*,' partly correspondent with that of the *Kolpodea* of Ehrenberg. This family comprehends "animals with a soft, flexible body, of variable form, but mostly oblong, and more or less depressed, provided with a loose reticulated integument, upon which numerous vibratile cilia are distributed in regular series. They also possess a mouth."

"*Lacrymaria*, and *Pleuronema*, would probably be more correctly placed in distinct families, the mouth in these being rather presumed than demonstrated. The other genera properly referable to the *Parameciens* are *Glaucoma*, *Kolpoda*, *Paramecium*, *Amphileptus*, *Loxophyllum*, *Chilodon*, *Panophrys*, *Nassula*, *Holophrya*, and *Prorodon;* of these, all but the last two have the mouth lateral. *Chilodon*, *Nassula*, and *Prorodon*, have teeth."

Those genera, which are peculiar to Dujardin, will be found appended at the end of the families of Ehrenberg, with which they have the nearest relation.

Paramecium *aurelia* (M.)—Body club-shaped cylindrical, slightly attenuated anteriorly. An oblique longitudinal fold borders upon the very receding mouth. Ehrenberg states that he has seen small dark crystalline bodies abundant in the frontal region, which, he conceives, are indications of the presence of nervous matter, as such crystalline bodies often accompany it. These creatures appear to have the sense of taste; and in the same group some individuals prefer one kind of food, and others another. This interesting fact may be observed by mixing blue and red colours together, when some will feed upon the former, others upon the latter, as indicated by the colour of the digestive cells: in some the cells have a violet hue. These animalcules, fed with colour, may be dried upon glass or mica, and thus preserved. The rays of the star-like vesicle Ehrenberg considers as *ductus spermatici;* they are long, and enter the ovarium at many points. The expulsion of ova has frequently

been observed. The colour of these animalcules, when bearing ova, is white by reflected light, and yellow by transmitted, hence the names "gold and silver little fishes," so often applied to them by Joblot and others; those devoid of ova are colourless. The cilia are best seen when the water is coloured; there are from twenty-six to fifty-two longitudinal rows along each side of the body; in some rows Ehrenberg counted from sixty to seventy cilia which gives 3640 organs of locomotion; each cilium is placed upon a sort of little knot. Fig. 329 represents an animalcule dried from clear water; fig. 330 is a view of a creature feeding upon indigo, which latter indicates the currents produced by its cilia; fig. 332 is an ideal view, to show the structure of the nutritive organs, as stated by Ehrenberg; fig. 331 is a young specimen of the normal shape, hence not produced by self-division. This species is abundant in vegetable infusions, and increases so rapidly in stagnant waters, both by ova and self-division, that some have thought they were produced spontaneously from elementary primal matter. Size 1-120th to 1-96th.

PARAMECIUM *caudatum*.—Body spindle-shaped, obtuse anteriorly, but attenuated posteriorly. Not found in infusions, but in ponds amongst decayed sedge leaves and Conferva. Size 1-120th.

P. *chrysalis* (M.)—Body oblong and cylindrical, equally rounded at both ends; cilia about the mouth very long. This species, like *P. aurelia*, is often developed in such vast myriads that the water has a milky hue, the masses ascending or descending in the fluid: this appearance may be produced by slightly shaking the water. Found in infusions and in salt water. Size 1-240th to 1-190th.

P. *Kolpoda* (*Kolpoda ren*, M., *K. cucullus*, D.)—Body ovate, slightly compressed; ends obtuse, the anterior attenuated and slightly bent like a hook. Found especially in infusions of Urtica dioica (the stinging-nettle). Size 1-240th.

P. (?) *Sinaiticum*.—Body elliptical, compressed, the back and under side carinated (keeled); frontal cilia indistinct. Found, amongst Conferva, in a brook on Mount Sinai. Size 1-288th.

P. (?) *ovatum*.—Body ovate, turgid; anteriorly attenuated and rounded. Found in stagnant river water. Size 1-288th.

P. *compressum* (*P. aurelia*, M., *Plagiotoma compressum*, D.)—

Body elliptical or reniform, compressed. An oblique wreath of long cilia reaches to the middle, where the mouth, with its slight tongue-like process, is situated. Found in the river mussel (Mya). Size 1-240th to 1-210th.

PARAMECIUM *milium* (*Cyclidium milium*, M.)—Body small, oblong, trilateral; rounded equally at both ends. In coloured water the body is seen vibrating. Size 1-1150th.

Genus AMPHILEPTUS.—*The double-necked Animalcules* have neither tongue-like process nor eye, but are provided with a proboscis and tail. Body elongated, fusiform or lanceolate. In three species the organs of locomotion are numerous cilia disposed in longitudinal series; in one, cilia are not visible, but in this the flexible attenuated extremities of the body serve their office. In some, the tail (foot) and proboscis (brow) are rudimentary. In five species numerous digestive cells, filled with food, may be seen; in seven the mouth is distinct; and in five of them a discharging opening. All have a colourless digestive juice, except *A. margaritifer*, in which it is pale rose-red. Ova granules are observable in seven species, in one are green, in the others whitish. In four species a contractile vesicle is seen; in three sexual glands, which in two are globular, double, and moniliform in the third self-division, has been observed: in one species it occurs transversely and longitudinally, and in another transversely only. The figures of this genus were engraved before I discovered Dr. Ehrenberg had not arranged his illustrations according to the classification.

Speaking of M. Ehrenberg's distribution of this genus, Dujardin remarks, "this author whilst assigning as characteristic, the presence of a proboscis and tail, yet places among it, as species, animalcules without tail, and dilated or rounded posteriorly; and on the other hand, ever seeking a distinctive character for his different families, in the position of the anus, which he attributes to all his enterodelous Infusoria, he has left in his genus *Trachelius*, several species, which to us appear to belong to *Amphileptus*, and has himself several times transferred some species from one genus to the other."

The *Amphileptus anser* is taken by Dujardin as the type of a genus termed *Dileptus*, and *A. meleagris* of a genus *Loxophyllum*.

The *Amphilepti* are commonly found in the limpid water of marshes or brooks, among aquatic plants.

AMPHILEPTUS *anser* (*Vibrio anser et cygnus*, M. *dileptus*, D.)—Body turgid, spindle-shaped; proboscis obtuse, same length as body; tail short and acute. The neck-like proboscis is truly a brow or upper lip, the mouth being at the base. Ehrenberg thinks he has seen the anal opening upon the dorsal surface, near the tail. The motion of the body is slow, but that of the proboscis more active. Figs. 312, 313, represent two views of this creature. Found amongst dead sedge leaves, &c. Size 1-120th.

A. *margaritifer.*—Body white, slender, spindle-shaped; proboscis acute equals the length of the body; tail short. The most striking features are the swollen margin of the mouth, and necklace-like series of vesicles disposed along the body. It feeds upon green Monads, like the preceding species. Cilia are absent in Ehrenberg's figures. Found amongst colonies of Vorticella, &c. Size 1-72nd.

A. *moniliger.*—Body turgid, ample, white; proboscis and tail short; it has a necklace-like gland. Found amongst duck-weed. Size 1-96th to 1-72nd.

A. *viridis.*—Body turgid, spindle-shaped, and of a green colour; proboscis and tail short and transparent. Found amongst Lemna minor. Size 1-120th to 1-96th.

A. *fasciola* (*Vibrio anas fasciola et intermedius. Paramecium fasciola*, M.)—Body white, depressed, linear, lanceolate, convex above, flat beneath. When viewed from above, from ten to twelve longitudinal series of delicate cilia may be seen, and in the middle of the body two round glands, posterior to which is a sexual vesicle, and ova granules between the digestive cells. Figs. 314, 315, 316 represent three views of this creature. Found in infusions. Size 1-720th to 1-144th.

A. *meleagris* (*Kolpoda*, M., *Loxophyllum melagris*, D.)—Body large, compressed, membranous, broadly lanceolate in shape, with the crest of the back denticulated. The colour of this interesting animalcule is white. On the under side there is a more or less distinct row of eight to ten bright colourless spots (juice-bladders). Found with Lemna. Size 1-72nd.

A. *longicollis* (*Kolpoda ochrea, Trichoda felis*, M.)—Body dilated;

turgid posteriorly; attenuated and elongated anteriorly, like a sword. Found amongst Lemna. Size 1-120th to 1-96th.

AMPHILEPTUS (?) *papillosus.*—Body depressed, lanceolate, fringed with papillæ; tail and proboscis smooth. Found amongst Conferva. Size 1-600th to 1-430th.

Genus UROLEPTUS.—*The train Animalcules* have a tail, but neither eye, tongue-like process, nor proboscis. Locomotion is effected by cilia, which in three species are disposed in rows. The polygastric apparatus has been demonstrated by coloured food in two species, and the mouth in all of them, but a discharging orifice has not been satisfactorily determined. Green coloured ova granules are evident in two species, but no male organs.

This genus of Ehrenberg, says M. Dujardin, judging from the figures of most of its species, should be in part united with *Oxytricha.* Thus *Uroleptus piscis* seems identical with *Oxytricha caudata* (Duj.); *U. musculus* (Ehr.) is, in figure, an *Oxytricha,* whilst *U.* (?) *lamella* is probably a *Trachelius,* and *U. filum* is rather allied to *Spirostomum ambiguum.*

Thus if Dujardin's views be correct, *Uroleptus* should be erased from the list of genera.

U. *piscis* (*Trichoda piscis,* M.)—Body like an elongated top; gradually attenuated posteriorly, forming a thick tail; ova greenish. Body covered with cilia, those at the mouth largest. Found, in February and March, amongst the floccose brown coat upon dead sedge leaves, along with *Chlamidomonas* and *Cryptomonas.* Hampstead ponds. Size 1-288th to 1-44th.

U. *musculus* (*Trichoda musculus,* M.)—Body white, cylindrical, pear-shaped, thickened posteriorly, where it abruptly terminates in a tail, (fig. 333, P. 7.) The movement is rolling. It is inactive and rigid. Found with Oscillatoria. Size 1-220th.

U. *hospes.*—Body greenish, ovato-oblong, and turbinate in shape; obliquely truncated and excavated anteriorly; posteriorly terminated by a styliform, acute tail. Found in the cells of frog and snail spawn. Size 1-240th.

U. (?) *lamella.*—Body transparent, linear-lanceolate, depressed, flat, very thin. Found in infusions. Size 1-220th.

U. *filum* (*Enchelys caudata,* M.)—Body white, filiform, cylin-

drical, rounded anteriorly, attenuated posteriorly, forming a straight long tail. It is considered a *Spirostomum* by Dujardin. Found in stagnant spring water, &c. Size 1-48th.

Genus OPHRYOGLENA derives its name from the animalcules possessing an eye anteriorly, and having a ciliated ovoid body. Locomotion is effected by numerous regular longitudinal series of cilia. The numerous digestive cells are often filled with Naviculæ, and in one species they have been demonstrated by indigo. The mouth is situated in a cavity beneath the brow to one side, and the discharging orifice upon the dorsal surface, at the base of the little tail. The ova granules are brown in one species, black in another, and yellow in the third. A large central gland exists in one species, and contractile sexual vesicles in the others; transverse and longitudinal self-division has been observed in one species. A system of sensation is indicated by the presence of a large red or black visual organ, always present on the frontal region. These Infusoria are found in stagnant fresh water, but not in infusions.

O. *atra* (*Leucophra mamilla*, M.)—Body blackish, ovoid, compressed, acute posteriorly. The cilia are white, the eye black, and situated near the frontal dorsal margin. The mouth aperture forms a funnel shaped cavity, commencing immediately beneath the brow; within this cavity Ehrenberg thinks he has lately seen an oval bright gland. The white cilia appear like silver fringe, especially those in front. Found in turf hollows. Size 1-180th.

O. *acuminata.*—Body brown-coloured, ovate, and compressed; tail short and acute; eye red. The brow projects beyond the mouth about the length of the body, or, in other words, is situated about the middle. Figs. 334, 335, are two views of the same animalcule. Found in turf hollows. Size 1-180th.

O. *flavicans.*—Body yellow, turgid, ovate, attenuated and rounded posteriorly, eye red; the cilia near the mouth longer than in the preceding species; Ehrenberg counted from twelve to sixteen rows at one view. Found in turf hollows. Size 1-144th.

The additional genera to be here added from Dujardin are, *Dileptus* and *Loxophyllum.*

Genus DILEPTUS.—This genus belongs to the family 'Tricho-

diens,' and is thus defined: animal with a fusiform body, much elongated anteriorly, like a long neck, with a mouth seated at the base of the prolongation; vibratile cilia cover the surface, and are of larger size in front and near the mouth.

Ehrenberg has arranged the *Dileptus* with the *Paramecièns*, although, unlike the latter, destitute of a contractile reticulated integument.

The type of this genus *Dileptus* is the *Amphileptus anser* of Ehrenberg; and the *A. Margaritifer* (Ehr.) is referable also to it.

A new animalcule is thus described, under the name of *Dileptus folium:* body very flexible, lanceolate, contracted in front, with nodular reticulated and irregular stripes, like the veins of a leaf. Length 1-175th to 1-130th. Found in river water. (P. 21, fig. 26.)

Genus Loxophyllum (Duj.)—Body very depressed, lamellar, oblique, very flexible, and sinuous, or undulated along the borders; mouth lateral; cilia in wide parallel rows.

M. Ehrenberg has comprehended *Loxophyllum* with *Amphileptus*. *Loxophyllum meleagris*, the type of the genus, is the *Amphileptus meleagris* (Ehr.) (P. 21, fig. 32.)

The *Trachelius meleagris* (Ehr.) it is probable also represents another *Loxophyllum*, as also the *Kolpoda ochrea* of Müller, which Ehrenberg represents as agreeing with his *Amphileptus longicollis.*

Family.—OXYTRICHINA.

This family contains all polygastric animalcules which possess an alimentary canal with two separate orifices, neither of them situated at the extremities, without lorica, but provided with setæ, vibratile cilia, and non-vibratile styles or uncini. These locomotive organs are variously situated, and render the creature active. The polygastric cells, disposed upon an alimentary tube, have been demonstrated by Ehrenberg, and in *Ceratidium* only are indistinct. The mouth and discharging orifice, ova-like granules (at certain periods), and male organs (glands and vesicles), are each seen in four genera. Complete transverse and longitudinal self-division is observed in

three genera, but no gemmæ or buds. Eyes have not been detected.

Cilia and setæ—no styles or uncini	brow without horns	Oxytricha.
	brow with horns	Ceratidium.
Styles, or uncini, or both	with uncini—no styles..................	Kerona.
	with styles—no uncini..................	Urostyla.
	with styles and uncini..................	Stylonychia.

This family *Oxytrichina* is generally similar to the *Keroniens* of Dujardin, a family of animalcules, according to this observer, much lower in the scale than many in the families previously described, such as *Kolpoda, Paramecium, Coleps,* &c.

"*Processes* in the form of styles or hooks, characterise both the '*Keroniens*' and the '*Plœsconiens,*' but the latter have a shield (lorica), whilst the former are soft, and have no sign of an integument. Of the '*Keroniens,*' the *Oxytricha* have no horns or hooks, but only cirrhi or straight processes, and in appearance rigid; another genus, '*Halteria,*' has large cirrhi like the preceding, but differs considerably in its mode of life and its movements.

"The *Urostyla* of Ehrenberg, with styles only and no hooks (uncini), we unite with *Oxytricha,* and his *Stylonychia,* provided with both styles and hooks, with *Kerona;* another genus described by Ehrenberg under the name of *Ceratidium,* horned anteriorly, but wanting both styles and hooks, seems to be but altered or mutilated *Keronæ.* On the other hand the *Halteria* appear to be included by Ehrenberg among true *Urceolaria,* in his genus *Trichodina,* although it possesses none of the characters. The Keroniens are found in stagnant water, fresh and salt."

Genus Oxytricha.—*The hatchet Animalcules* are destitute of styles and uncini, and unprovided with horns. The body is soft, flexible, oval or oblong, and more or less flattened. They possess cilia and setæ, the latter resembling rigid hairs; their movements are forwards and backwards, often by impulses, creeping, swimming, and climbing; locomotion is effected by the cilia. In all the species polygastric cells are evident, in five ova-like granules, in four male glands, and in five round sexual vesicles. Transverse and longitudinal division is observed in *O. lepus* and *O. pelionella;* longitudinal only

in *O. cicada*, and perhaps *O. pullaster*. The *Trichoda nasamomum*, and *T. œthiopica* (Ehr.) belong, in Dujardin's opinion, to *Oxytricha*, so also the *Urostyla*, whilst *Oxytricha cicada* (Ehr.), becomes a species of *Plœsconiëns*.

OXYTRICHA *rubra* (*Trichoda piscis et patens*, M.)—Body of a brick-red colour, linear in shape, plane on the under side, and equally rounded at the ends; posterior end provided with setæ. Found in sea water. Size 1-140th.

O. *pelionella* (*Trichoda pelionella*, M.)—Body white, smooth, slightly depressed, equally rounded at both ends, often broader in the middle ; head not separate ; mouth ciliated ; tail provided with setæ. Each animalcule has two oval male glands, and between them a single round sexual vesicle. When self-division commences four glands are developed, and then the vesicle divides. Ehrenberg counted ten cilia anteriorly, and four or five setæ posteriorly ; the anal outlet is at the base of the setæ. Found in infusions. Size 1-720th to 1-280th.

O. *caudata*.—Smooth, white, linear-lanceolate in shape, rounded anteriorly, attenuated posteriorly in the form of a tail, which is provided with setæ. Found in fresh water and sea water. Size 1-576th to 1-120th.

O. *platystoma*.—Body white, ovato-oblong, under side flat, with marginal setæ ; mouth large and ciliated. It swims with a revolving and vascillating motion, and often upon the back. It creeps upon water plants. Found in standing bog water. Size 1-240th.

O. *gibba* (*Trichoda gibba et fœta*, M.)—Body white, lanceolate, ends obtuse, middle enlarged, under side flat and furnished with two series of setæ, and a large round mouth. This species resembles *O. pelionella*, but is distinguished by the setæ, the two or three contractile vesicles, and sexual glands. This creature is active, and runs nimbly along aquatic plants in fresh and brackish water. Fig. 336 is an under view, fig. 337 a side view. Size 1-240th.

O. *pullaster* (*Trichoda pullaster*, *Kerona pullaster*, M.)—Body whitish, lanceolate, ends obtuse; ventral surface naked at the middle; the head, indicated by a constriction, is hairy, like the tail. The mouth is a narrow fossa. Found in water vessels and infusions. Size 1-430th.

OXYTRICHA *cicada* (*Trichoda cicada,* M.)—Body ovate or almost hemispherical, back furrowed and notched, under surface flat. Found upon the surface of stagnant water. Size 1-1440th to 1-860th.

O. *lepus.*—Body whitish, elliptical, smooth, flat; ciliated anteriorly; provided with setæ posteriorly; the mouth and discharging orifices not distinct; Ehrenberg has not seen the male generative apparatus. Found in standing water. Size 1-540th to 1-96th.

The following additional species of *Oxytricha* are given by Dujardin.

O. *incrassata.*—Body ovoid, long, colourless, fringed posteriorly, with rigid setæ. It is not so long as *O. pelionella,* and unlike it is marine. Length 1-350th. In Mediterranean.

O. *lingua.*—Body diaphanous, flattened, flexible, elongated, rounded at each end without setæ or apparent cilia posteriorly; granules of surface in nearly regular rows. Length 1-212th. In ditch water with Confervæ.

O. *ambigua.*—Body colourless, oval, oblong, depressed in the middle, concave on one side, margin tumid; furnished with very strong locomotive cilia, on the concave surface and with rigid setæ behind. Length 1-350th. Found in sea water.

O. *radians.*—Body discoid, red, surrounded by long radiating setæ. Length 1-520th. In salt or brackish water.

Genus CERATIDIUM.—*The horned Animalcules* have cilia, horns on the frontal region, but no styles or uncini. But little of their organization is known, and therefore the situation of the species is uncertain. It requires a power not less than 350 to exhibit it.

C. *cuneatum.*—Body triangular, front truncated, as also the two horns, upper side smooth. Ehrenberg found this whitish animalcule in 1820 amongst Conferva, but has not lately seen it. Dujardin believes it to have been a mutilated *Oxytricha.* It vibrates, runs, and climbs quickly. Figs. 338, 339, represent two views of this animalcule. Size 1-430th.

Genus KERONA.—*The claw Animalcules* are provided with cilia and uncini, but not with styles. The body is soft, flexible, oval and flattened, and ciliated, and has upon the under surface claws, and perhaps setæ. Numerous digestive cells indicate the polygastric

structure; the mouth, and probably the anal spot, are upon the ventral surface. The propagative system is double, consisting of ova glands, and a contractile vesicle. Self-division has not been observed.

In this genus *Kerona,* Dujardin also includes the *Stylonychia* of Ehrenberg, not considering the slight difference in their appendages, sufficiently distinctive to separate them into two genera.

The *Kerona* thus understood, differ from *Oxytricha* only in the form of their cirrhi or processes, the base of which is commonly dilated in the form of a transparent ball, and moveable withal. They are, however, equally voracious and abundant in stagnant water and infusions.

Kerona pustulata, (Duj.) = *Stylonycha pustulata,* (Ehr.,) *K. histrio* = *S. histrio; K. mytilus* = *S. mytilus.* But *K. pullaster* would rather seem analogous to *Oxytricha pullaster,* (Ehr.)

The only species of *Kerona* mentioned in Dujardin's work, and not included in that genus, or in *Stylonychia* by Ehrenberg, are—*Kerona calvitium,* and *Trichoda faveata* of Müller, two names indicating varieties of the same species, which varies in the number and size of its appendages. It is oblong, with styles projecting anteriorly; flattened and obtuse at each end.

Kerona *polyporum.*—Body whitish, depressed, elliptical, and reniform; it has a series of cilia around the frontal region, produced from below the mouth; Ehrenberg counted above forty digestive cells, many of them filled with brownish (half-digested green) Monads. Between the cells are ova granules. Fig. 340 is a back view, and fig. 341 a side view, climbing. Parasitic on Hydra vulgaris. (*See* 'Microscopic Cabinet,' pl. 7.) Animals infested with them die. Size 1-144th.

Genus Urostyla.—The *style Animalcules* are provided with cilia and styles, but are destitute of uncini; the cilia are thickly disposed in numerous series, those near the mouth being longest. On the ventral surface, at the posterior end, is a small cleft, provided with non-vibratile setæ. The numerous digestive cells receive colour and large bodies; a gland, a contractile sexual vesicle, and delicate granular ova, represent the propagative system. Transverse self-division also has been observed.

Urostyla *grandis.*—Body white, semi-cylindrical, rounded at the ends; anteriorly slightly enlarged, hence club-shaped; styles short, mouth cleft, large, 1-4th to 1-3rd the length of the body; it has long cilia on both sides; the discharging orifice has from five to eight little styles on the left side only; the stomach juice is colourless. The young animalcules are flatter than the old ones. Fig. 342 represents an under view with glands, vesicle, and the cells filled with Bacillaria and coloured matter. Currents produced by the vibration of the cilia about the mouth are also indicated in the drawing. Found on slimy dead sedge leaves. Size 1-144th to 1-96th.

Genus Stylonychia.—*The armed Animalcules* are ciliated, and armed with styles and uncini. These organs of locomotion are variously disposed. In one species the course of the alimentary canal, with its numerous digestive cells, has been seen; in the others coloured food is received in the cells; a thick granular ova cluster exists in all the species; in two of them two glands; and in four, contractile vesicles. Transverse and longitudinal self-division occurs in two species; transverse only in a third, and in *S. pustulata*, the formation of gemmae is seen.

S. *mytilus* (*Trichoda mytilus, Kerona mytilus*, M.)—Body white, flat, oblong, slightly constricted in the middle, obliquely dilated anteriorly in the form of a mussel. The extremities are so transparent that they give it the appearance of being covered with a shield, but they are soft, flexible, and furnished with cilia. The stomach juice is colourless, the middle of the body is sometimes filled with delicate white granules (ova). This animalcule generally has a peculiar thrusting forward and back movement, but can climb, run, and swim nimbly, usually with the back undermost. Dr. Ehrenberg found a single animalcule lived nine days: during the first twenty-four hours it was developed by transverse self-division, into three animals; these in twenty-four hours more formed two, in the same manner; so that, by self-divison only (without ova), these animalcules increase three or four-fold in twenty-four hours, and thus a million may be produced from a single animalcule in ten days. An abundant supply of food favours self-division. Found in infusions and amongst Oscillatoria. Size 1-240th to 1-96th.

S. *pustulata* (*Trichoda acarus*, M.)—Body white, turbid, ellip-

tical, attenuated at both ends; and having a band of uncini at the middle of the belly. Ehrenberg has seen transverse and longitudinal division, and the growth of gemmae. Found in infusions. Size 1-144th; ova granules 1-24000th.

STYLONYCHIA *silurus* (*Trichoda silurus, Kerona silurus, Hymentopus lava, &c.*, M.)—Body small, white, of the form of a mussel; cilia and uncini rather long. Found in fresh water. Size 1-280th.

S. *appendiculata.*—Body elliptical, white, small, and flat; cilia and styles long; the setæ disposed obliquely in fascicles. Found in fresh water. Size 1-280th.

S. *histrio.* (*Paramecium histrio, Kerona histrio,* M.)—Body elliptical, white, middle slightly turgid, finished anteriorly with a cluster of uncini; no setæ. Dr. Ehrenberg states the absence of the three posterior setæ in this and the following species is remarkable, inasmuch as the others possess them. Found amongst Conferva. Size 1-280th.

S. *lanceolata.*—Body pale greenish, lanceolate in shape, extremities equally obtuse, under side flat; it has uncini in a cluster near the mouth, but no styles. Ehrenberg saw in one specimen a simple contractile vesicle on the left side, below the mouth, and near it a large oval gland. Green Monads and Bacillaria may be seen in this voracious animal, surrounded with colourless stomach juice. Fig. 343 represents an under view, and fig. 344 the side view of another. Found amongst Conferva. Size 1-144th to 1-120th.

The only genus to be appended to this family is the one called by Dujardin—

HALTERIA.—Body nearly globular or turbinate, surrounded by long, very fine retractile cilia, which adhere to the glass, and then contracting suddenly, enable the animal to change its place briskly, as if by leaping; a row of very strong oblique ciliæ occupies the circumference.

The type of this genus is *Halteria grandinella,* (f. 31, a, b, c, P. 21,) called by Ehrenberg *Trichodina,* and placed by him in the family *Vorticellina,* along with species totally different, and which Dujardin terms *Urceolaria.*

FAMILY.—EUPLOTA

Have a lorica and alimentary canal, with two separate orifices, neither of which are terminal. They possess powerful organs of locomotion, similar to those of the preceding family.

This family resembles in many respects the genus *Asellus* of the Entomostraca, whose organization is so highly developed: hence this family very properly closes the grand division Polygastrica. Organs subservient to nutrition are distinctly seen in three genera—one is marked by having a cylinder of wand-like teeth, and a beautiful rose-coloured digestive juice, like the genus *Nassula*. The propagative apparatus is double in three genera, ova granules are found in two, male glands in two, a contractile vesicle in three; self-division, transverse and longitudinal, is observed in one, but gemmae are not produced. One form is green, the others are colourless and whitish.

This family comprises the following genera:—

With cilia—no styles.	teeth absent	head distinguished from the body	Discocephalus.
		head not distinguished from the body...	Himantophorus.
	teeth present		Chlamidodon.
With cilia, claws, and styles			Euplotes.

This family *Euplota* in part corresponds with that of the *Plœsconiens* of Dujardin, which includes animalcules of an oval or reniform depressed figure, not contractile, and only slightly flexible, but invested with an apparent shield (lorica), which, however, undergoes diffluence like the softer parts. Mouth furnished with vibratile cilia, and often also with cirrhi, in the form of styles or moveable hooks. They swim by means of the vibratile cilia, or crawl by the aid of the other appendages.

The *Plœsconiens* form five genera:—*Plœsconia* and *Chlamidodon,* with a visible mouth, the latter also having teeth; *Diophrys* and *Coccudina,* without visible mouth; the cirrhi or processes in the former, grouped at the two ends, in the latter covering the under surface. *Loxodes* has only vibratile cilia.

The animalcules of the genus '*Plœsconia*' seem for the most part identical with the *Euplotes* of Ehrenberg, but as the identification is in some cases uncertain, and as several new species are described by Dujardin, we shall subjoin the *Plœsconia,* as constituting an appended genus along with *Diophrys* and *Coccudina.*

Genus DISCOCEPHALUS.—*The disc-headed Animalcules* have neither styles nor teeth, but possess uncini, and have the head distinguished from the body (capitate). The organization is unknown, only the non-vibratile uncinated locomotive organs having been specially observed.

D. *rotatorius.*—Body transparent, flat; head smaller than the body; both rounded. Fig. 345 is an under, and fig. 346 a side view. Found in the Red Sea. Size 1-380th.

Genus HIMANTOPHORUS.—*The whip-footed Animalcules* are distinguished by the absence of styles and teeth, by having numerous uncini, and not having the head distinct from the body. The long bent hooks, generally in pairs, appear like a broad band upon the under side, serving as organs of locomotion; near them is a row of cilia extending from the mouth to the middle. The mouth, discharging orifice, and numerous digestive cells, are distinct. At the posterior margin is a large contractile vesicle; between the row of cilia and margin on the right is a series of glandular spots. Self-division has not been observed.

H. *charon* (M.)—Body transparent, flat, elliptical, anterior slightly truncated obliquely, cilia short, uncini long and slender. The mouth commences anteriorly at the lower angle of the triangular bright spot, but the true œsophageal opening appears to be at the end of the row of cilia within the curved lorica; the posterior alimentary opening is nearly at the base of the last cluster of four to six comb-like uncini, which supply the place of styles. Fig. 347 is a side, and fig. 348 an under view. Found in water vessels that have stood some time. Size 1-180th.

Genus CHLAMIDODON.—*The toothed Animalcules* possess cilia and teeth at the mouth, but no styles or uncini; an oval transparent lorica or shield covers the back, and projects around it; a margin of cilia surrounds the body, these are longer near the brow; short climbing setæ probably exist posteriorly, between the cilia.

Polygastric cells are distinct, as also vesicles containing a beautiful rose-coloured digestive fluid; the mouth has a hollow cylinder of wand-like teeth. Minute green ova granules (?) and a large oval bright central gland represent the propagative organs. Self-division unknown.

CHLAMIDODON *mnemosyne.*—Body flat, elliptical, sometimes dilated anteriorly, as shown at fig. 349. It is of a clear green or hyaline hue, with brilliant rose-coloured vesicles; delicate longitudinal lines are seen upon the surface of the animalcule, and appear to be on the lorica. Ehrenberg counted sixteen wand-like teeth disposed cylindrically. The movement is quick and powerful, as in *Euplotes*. Found with Zostera and Scytosiphon. Size 1-570th.

Genus EUPLOTES.—*The skiff-like or boat Animalcules* possess cilia, styles, and uncini, which are powerful locomotive instruments, but no teeth. Polygastric cells have been filled in four species with coloured food; in the others bright vesicles evidence them; the termination of the alimentary canal is indicated in one species by the discharge, in the rest by the projecting little shield; the digestive juice is colourless; the propagative organs are probably double in seven species, in one completely so. White ova are seen in four species; oval or round simple glands exist in three; a single contractile vesicle in five; and in a sixth two vesicles are observed. Self-division, transverse and longitudinal, has been observed in one species, and transverse only in two or four others.

E. *patella.*—Lorica large, nearly circular, slightly truncated anteriorly; margin transparent, broad; back elevated, gibbous, and covered with a few delicate smooth striæ. The mouth is ciliated on each side, the œsophagus is near the side, lower than the middle, the discharging orifice behind the base of the styles. Found with Lemna. Size 1-280th.

E. *Charon* (*Trichoda Charon*, M.)—Lorica small, ovato-elliptical, slightly truncated anteriorly, and having granular striæ on the back; twenty to forty cilia were counted by Ehrenberg, but no setæ; white ova, propagative glands, and a contractile vesicle, have been seen. Figs. 350 — 353 represent different views. Found in standing water and infusions. Size 1-1150th to 1-280th.

Euplotes *striatus*.—Lorica oblong, elliptical, slightly truncated anteriorly, uncini only upon the posterior part of the body; four smooth striæ upon the back. Found in sea water. Size 1-240th.

E. *appendiculatus*.—Lorica ovato-oblong, ends rounded, provided with oblique styles, and four straight setæ upon the posterior part of the body. Found in sea water. Size 1-240th.

E. *truncatus*.—Lorica oblong, with smooth striæ, unequally truncated, and notched anteriorly. It has setæ and numerous uncini. The styles are straight. Found in sea water. Size 1-240th.

E. *monostylus*.—Lorica elliptical, ends rounded, no striæ. It has a single style, like a tail, but no uncini. Found in sea water. Size 1-400th.

E. *aculeatus*.—Lorica oblong, nearly square, ends rounded; it has two crests upon the back, one bearing a little spine in the middle. Found in sea water. Size 1-430th.

E. *turritus*.—Lorica smooth, nearly circular; it has a long erect spine on the centre of the back. Size 1-600th to 1-430th.

E. *cimex* (*Trichoda cimex*, M.)—Lorica oblong, elliptical, and smooth, provided with cilia, styles, and uncini. Found in sea water. Size 1-430th.

E. *viridis*.—Lorica large (ample), oblong, truncate in front, with a central obtuse tooth, dorsum flat; ova green. Size 1-480th. Berlin.

Genus Ploesconia (Duj.)—Body oval, more or less flattened, enclosed by an apparent lorica, marked by longitudinal ribs, furnished mostly on one of its plane surfaces with scattered cilia, fleshy, thick, and in the form of stiff hairs, or of non-vibratile hooks, yet moveable, and serving the purpose of feet; on the other surface, having a row of vibratile cilia regularly placed, and becoming finer as they recede from the anterior to the posterior end, where the mouth is situated, and towards which they vibrate.

In my opinion, adds Dujardin, a *Ploesconia*, notwithstanding its apparent complexity of structure, is yet an animal as simply organised as those previously considered; having a simple, fleshy, homogenous substance, assuming during life a rather complex form, which is lost at the moment of death, no membrane or fibre sustaining it. The cilia or cirrhi of varied form are still of the

same nature, and I would say, of nearly the same consistence. They have a mouth also, but no anus; vacuolæ formed at the bottom of the mouth, as a result of an impulsive force, produced by the vibratile cilia on the surrounding liquid, hollowed out in any part; and lastly granules, varying in kind, desseminated through the mass, and which I cannot admit as determinate organs, or as ova. This account varies materially from that of Ehrenberg.

Ploesconia *patella* = *Euplotes patella.*—*P. vannus.*—Body depressed, oblong, oval; very transparent, smooth, without striæ, 5—8 anterior hooks; and 7—8 straight styles behind. Length 1-218th. In sea water.

P. (?) *sentum.*—Larger than the preceding, with the band of vibratile cilia extending farther backwards, and the posterior styles inflected and sinuous.

P. *balteata.*—Body oval, rather narrower in front, diaphanous, with 5 striæ (ribs); the band of cilia extending 5-6ths the length of the body; cirrhi few, feeble. Length 1-325th. In sea water; no hooks, as in *P. vannus.*

P. *cithara.*—Body oval, with ten regularly disposed ribs, well marked; the row of cilia semicircular, extending two thirds its length; cirrhi not long, and almost confined to the posterior extremity. Length 1-290th to 1-275th. In stagnant sea water.

P. *crassa.*—Body oval, oblong; thick, but diaphanous, with some faint signs of ribs; the band of cilia little curved, and extending one half the length; 6—8 curved cirrhi at anterior, and 5—7 straight ones at posterior extremity. Length 1-362d. Found with the preceding in sea water.

P. *Charon.*—Body irregularly oval, truncate in front, narrower behind, with well marked irregular ribs; cirrhi long, not curved. Differs much from *Euplotes Charon* (Ehr.)

P. *affinis* differs from P. *Charon,* by its habitat being in fresh water, and by having its anterior portion narrower, whilst its posterior is more rounded and less plaited.

P. (?) *subrotunda.*—Body oval, thick, granular within; no distinct ribs; truncated and fissured in front, styles long and thin at each end. Length 1-535th to 1-475th. In infusions.

P. (?) *radiosa.* Longer than the preceding, 1-520th to 1-395th,

with long styles radiating from each extremity. In river water.

PLOESCONIA *longiremis.*—Body very depressed, irregularly oval, dilated on the side supporting the cilia, where it is more transparent, with 3—4 large ribs, but slightly prominent; cirrhi numerous, very long and flexible. Length 1-400th to 1-306th. In sea water.

P. *aculeata* = *Euplotes aculeatus* (Ehr.)

Genus DIOPHRYS.—Body discoid, irregular, thick; concave on one side, convex on the other; with long cirrhi grouped at each end, no mouth.

D. *marina.*—Body oval, with a longitudinal excavation; terminated in front by 5 great vibratile cilia, and behind by 4—5 very long geniculate cirrhi. Length 1-580th. In sea water. (Fig. 22 *a b*, P. 21.)

Genus COCCUDINA.—Body oval, depressed, or nearly discoid, often rather sinuous on the margin; convex, pitted or granular, and glabrous above; concave below, with vibratile cilia and cirrhi or hooks, serving as feet: without mouth.

Intermediate between *Loxodes* and *Ploesconia*, having the appendages of the latter, and the general figure of the former. Ehrenberg has left the *Coccudina* known to him dispersed among *Oxytricha* and *Euplotes.*

C. *costata.*—Body oval, obliquely contracted, and sinuous in front; convex and furrowed beneath, where from 5—6 very prominent tubercular ribs are found, processes grouped at each end; the anterior thinner and vibratile. Length 1-965th. In marsh water.

C. *crassa.*—Body oval; larger, and seemingly truncated behind; contracted and sinuous in front; convex above, with feebly marked ribs; anterior processes in the form of hooks; posterior, of straight styles. Length 1-20th. Marine among corallines.

C. *polypoda.*—Body oval, sinuous in front; convex, and marked above with from 7—8 narrow ribs; flat below, and furnished with numerous long and flexible cirrhi. In stagnant sea water. (Fig. 30 *a b c*, P. 21.)

C. *cicada.*—Body oval, granular, very convex, margin rounded; concave beneath, and there provided with long and flexible cirrhi.

Length 1-812th. Appears the same as the *Trichoda acada* of Müller, but not as its supposed synonyme *Oxytricha cicada* (Ehr.) which is like the *Coccudina costata* rather than *C. cicada.*

COCCUDINA (?) *cimex* = *Stylonychia cimex* (Ehr.)

C. *reticulata*—a name provisionally applied to an animalcule found in the Seine, having a granular and reticulated surface, and large cirrhi at each end. Length 1-578th.

The genus *Aspidisca* (Ehr.) should, Dujardin believes, be numbered among the *Coccudina.*

CLASS II.—ROTATORIA.

Those infusorial animalcules which are included under the great division Rotatoria are distinguished by being destitute of a true nervous system, and of vascular pulsation; by possessing a simple tubular alimentary canal, a definite form of body, (that is, not alterable by the formation of gemmae, or spontaneous division, as in the Polygastrica;) by being androgynous, or hermaphrodite; provided with rotatory organs, and, though destitute of true articulated feet, often with a single false foot, or pediform process.

The magnifying power most useful for the examination of the Rotatoria is 200; and with a power of 400 times, all that has been discovered in their internal organization (except in one or two cases) may be seen.

The following table represents the analysis of the class Rotatoria into families:—

With a simple continuous wreath of cilia (MONOTROCHA.)	margin of cilia wreath entire. *Holotrocha.*	illoricated	Icthydina.
		loricated	Oecistina.
	margin of cilia wreath lobed or notched. *Schizotrocha.*	illoricated	Megalotrochaea.
		loricated	Floscularia.
With a compound or divided wreath of cilia (SOROTROCHA.)	with the cilia wreath divided into several series. *Polytrocha.*	illoricated	Hydatinea.
		loricated	Euchlanidota.
	with the cilia wreath divided into two series. *Zygotrocha.*	illoricated	Philodinaea.
		loricated	Brachionaca.

The above characters are according to Ehrenberg. With regard to the affinities of the class with respect to other groups of the animal kingdom, the reader is referred to Part I. of this Work; but, it may be remarked that Professor Owen considers the members of this class have the strongest affinity with the Crustacea, and consequently belong to the Province ARTICULATA, occupying a higher position than *Radiata* and *Entozoa*. On the other side, the Rotatoria has the nearest affinity with the Polygastrica through the Vorticella family.

Siebold adopts the classification of Ehrenberg for the *Rotatoria*, omitting, however, a few genera. Dujardin, on the contrary, regards the principles employed by Ehrenberg in framing his division of these animals as faulty and uncertain, and consequently puts forward one of his own. But he includes among his *Systolides*, for so he calls the *Rotatoria*, the curious animals named *Tardigrada*, which, although having some affinity with the true *Rotatoria*, are so wanting in all the essential characteristics of the latter, that no naturalist now thinks of associating the two together. Indeed at the time of publishing his book, Dujardin himself expressed doubts as to so placing them.

To resume, however, Dujardin formed four grand divisions of the *Rotatoria*, viz. 1. Those which live fixed by their posterior extremity. 2. Those which have but one mode of locomotion by means of their vibratile cilia, and are always swimmers. 3. Those which exhibit two modes of progression by crawling after the manner of leeches, and by swimming. 4. Those which creep by uncini, and are destitute of vibratile cilia.

This last division is constituted by the *Tardigrades;* the third comprises only the *Rotifera:* the first includes but two families, the *Floscularièns* and *Melicertièns*, whilst the second contains by far the largest number, which are distributed under two sections, according as the integument is flexible throughout, or in part solid, or otherwise constitutes a shield.

The last section so characterised is made up of the *Brachionièns*, and of the less characteristic families, *Polyarthra, Rattula*. The soft-skinned *Systolides* are represented in the families *Furcularièns* and *Albertièns*.

Mr. Howard has proposed the name Anneloida, to include the *Rotatoria, Annelida, Echinodermata,* and *Trematoda,* which he thinks form a natural group of animals.

The reader is referred for an account of the structure, and of other matters relating to the Rotatoria generally, to the several sections devoted to their consideration in Part I. In the following systematic account of these animals, the text of the first edition is generally followed, and consequently the description of the organization is in accordance with that given by Ehrenberg in his great work of 1838. More recent investigations, indeed, have brought into doubt some of the views entertained by Ehrenberg concerning the structure of *Rotatoria,* but still the present amount of knowledge on this point is not sufficiently extended and precise to warrant its employment to the exclusion of the matter supplied by the great naturalist of Berlin.

The reader must therefore bear in mind that Ehrenberg's hypotheses of organization colour the majority of the ensuing generic and specific description, whilst the general account of *Rotatoria* in Part I., represents the opinions of the structure and functions of particular organs entertained by others as opposed to those held by Ehrenberg. To a right understanding of this systematic description of the Rotatoria, the reader should be familiarly acquainted with the details of structure and function given in Part I., and then he may, if he pleases, read the description of organs, according to recent views of their function, in place of those advanced by Ehrenberg. Thus, when male vesicles, sexual glands, transverse vessels, respiratory tubes, &c., are spoken of, it would be remembered that others prefer to call the first named circulatory organs; the second, simply glands; the third, transverse or circular muscles; and the fourth, a solid process, or rudimentary antennæ.

FAMILY.—ICHTHYDINA.

Rotatoria with a single continuous rotatory organ, not cut or lobed at the margin. They are destitute of lorica or shell. In *Ptygura* and *Glenophora* the wheel-like organ is in the form of a circle, and serves for the purposes of locomotion; in the other

genera it is band-like, long, elliptical, and upon the ventral surface. A forked foot-like process is met with in *Chaetonotus* and *Ichthydium*, and a simple one in the others. A simple conical alimentary canal, with a long thin œsophagus, without teeth (?), is seen in *Ichthydium* and *Chaetonotus; Glenophora* has a short œsophageal portion, and two single teeth, and *Ptygura* an elongated stomach and three teeth. Pancreatic glands are seen only in *Chaetonotus* and *Ptygura;* neither cæcum nor gall-ducts are visible in any of the genera. The male reproductive organs not observed; the female consist, in two genera, of a large ovarium, with a few large ova. The two red frontal eyes, seen in *Glenophora*, are indications of the existence of a nervous system, and the bristly hairiness of the back of *Chaetonotus* is worthy of notice.

This family comprises the following genera:

Eyes absent	hair absent	with a simple truncated tail-like foot (*Pseudopodium*)........	Ptygura.
		with a forked tail-like foot..........	Ichthydium.
	hair (bristle-like) present........................		Chaetonotus.
Eyes present (two frontal)......................................			Glenophora.

This family is not admitted in Dujardin's system; but the genera *Ichthydium* and *Chaetonotus* are included among Infusoria (Polygastrica); whilst *Ptygura* is placed in the family '*Melicertièns;*' and *Glenophora* not recognised. Siebold likewise does not accept the genus *Glenophora*.

Genus Ptygura.—*The wrinkle-tailed Animalcules* are destitute of eyes and hair, but have a simple, truncated, cylindrical false foot. Body campanulate, oblong. Rotatory organ simple, and nearly circular. Numerous teeth-like bodies, adhering to the bulb of the œsophagus, two pancreatic glands, a small narrow œsophagus, an elongated stomach, and a globular-like rectum, constitute the apparatus of nutrition. An ovarium and a contractile vesicle have been observed; but neither longitudinal muscles nor visual organs, although carefully sought for.

This genus *Ptygura* is comprehended in the family *Melicertièns* of Dujardin, along with *Lacinularia*, *Tubicolaria*, and *Melicerta*, and is made to include the species distributed by Ehrenberg in the

several families *Ptygura, Oecistes,* and *Conochilus.* For Dujardin states that the individuals of these three genera present no further differences than in the gelatinous envelope, which surrounds the two last, forming in *Oecistes* a distinct tube for each individual, whilst it includes the individuals of *Conochilus* in a common globular mass, and is absent in *Ptygura.* The same author would name *Oecistes, Ptygura crystallina,* and the several *Conochili, Ptygura volvox.*

PTYGURA *melicerta.*—Transparent; body cylindrical, club-shaped, turgid anteriorly, with two little curved horns at the mouth, and a single short tube at the neck (?). The tail-like foot always remains transversely folded (wrinkled), as seen in fig. 354, P. 7, which represents the under side. When swimming, a ring-like simple vibratile organ is thrust out with a lateral notch. The two jaw-like parts of the œsophageal bulb have numerous teeth, as represented at fig. 355. Size 1-140th.

Genus DASYDYTES (Gosse.)—Eyes absent; body furnished with bristle-like hairs; tail simple, truncate.

This genus, according to Ehrenberg's description of *Icthydina,* must follow after *Ptygura.*

D. *goniothrix.*—Hairs long, each hair bent with an abrupt angle; neck constricted. Length 1-146th. Found at Leamington.

D. *antenniger.*—Hair short, downy; a pencil of long hairs at each angle of the posterior extremity of the body; head furnished with two club-shaped organs resembling antennæ. Length 1-170th.

Genus ICHTHYDIUM.—*The ciliated fish Animalcules* have a cleft or forked foot-like tail; no eyes or hair; currents at the mouth, and along the ventral side, indicate the existence of a vibratile organ, which not only serves for swimming, but likewise for creeping. A long œsophagus, a thick simple conical alimentary canal, and sometimes a large single ovum, comprise our knowledge of their organization. It is probable that a cylinder of little wand-like teeth exists.

I. *podura* (*Cercaria podura,* M.)—Body straight, oblong, often slightly constricted anteriorly, where it is turgid, and sometimes three-lobed. It is colourless or whitish, but during repletion sometimes appears yellowish; the ventral surface is flat and ciliated, the dorsal arched and smooth. The large dark ovum has been seen by

Ehrenberg. It seldom swims, but mostly creeps. Fig. 356 exhibits a full-grown animalcule (ventral side). Found among Conferva and Oscillatoria. Length 1-440th to 1-140th.

Genus CHAETONOTUS.—*The brushed fish-Animalcules* have hairs upon their dorsal surface, possess a forked tail, but no eyes. Locomotion is performed by a double row of cilia upon the ventral surface, forming a band-like rotatory organ. The nutritive organs consist of a tubular mouth, probably provided with a cylinder of teeth, a long thin œsophagus, and a long conical stomach (trachelogastricum), upon whose upper thick end (in the large species) two semi-globular glands are seen ; at certain periods, from one to three large ova are formed posteriorly, but the ovarium in which they are developed has not been directly observed ; male reproductive organs unknown. They are sluggish in their movements, except in creeping ; they rarely swim.

C. *maximus.*—Body elongated, slightly constricted anteriorly, turgid and obtusely three-lobed ; hairs upon the back short and equal. From the latest observations, Ehrenberg states the mouth to possess teeth, of which he has counted more than eight ; he once saw the exclusion of ova immediately over the hinder foot-like tail. It creeps but slowly. Size 1-216th to 1-120th.

C. *larus* (*Trichoda acarus anas et larus*, M.)—Body elongated, slightly constricted anteriorly, where it is turgid and obtusely triangular ; the posterior hair on the dorsal surface is longest. Ehrenberg has seen only one large ovum ; he states that the bodies of those bearing ova were thick posteriorly, though, under other circumstances, the head is broadest. It appears to have eight teeth. Pancreatic glands unknown ; the dorsal hairs, which are arranged in longitudinal rows, destroy the transparency of the body. Fig. 357 is a dorsal, and fig. 358 a side view. Ova 1-3rd the length of the body. Found in muddy water. Size 1-720th.

C. *brevis.*—Body ovato-oblong, slightly constricted near the turgid front ; dorsal hairs few, the posterior longest ; ova small. Size 1-340th.

As before stated, Dujardin places this genus *Chaetonotus*, together with *Ichthydium*, among the Infusoria (*Polygastrica*, Ehr.) ; in, however, a sub-class of them, called symmetrical, along with *Coleps*

and a doubtful genus, named *Planariola.* These genera in having a symmetrical figure, are distinguished by him from all other Infusoria.

One species of *Chaetonotus* described by Dujardin is probably new, although it may be, as he remarks, but the *C. maximus* of Ehrenberg. The following are its characters:

CHAETONOTUS *squamatus.*—Body elongate, narrowed on its anterior third, but expanded in its posterior half. Length 1-130th to 1-135th. Covered with short hairs; dilated in a scale-like form toward the base, and regularly imbricated. Found in sea water brought from Toulouse, long kept.

Genus SACCULUS (Gosse).—One eye, frontal; body destitute of hair, and without a foot; rotatory organ a simple wreath; alimentary canal very large; jaws set far forward, apparently consisting of two delicate unequal *mallei* and a slender *incus;* very evanescent; eggs attached behind, after deposition.

This genus comes nearest to *Glenophora,* but, unlike the latter, has but one eye.

S. *viridis.*—Body pear-shaped; flattened ventrally, the anterior end the narrower; head conical pointed, surrounded by a wreath of long cilia; digestive canal occupying nearly the whole body, and always filled with a substance of a rich green hue in masses. Length 1-150th. This curious animal (found in considerable number in a little pool on Hampstead Heath) must be placed in this family, according to Ehrenberg's system, but the mode of carrying its eggs indicates an affinity with the *Brachionoea.*

Genus GLENOPHORA.—*The eye Animalcule* is characterised (as its name imports) by the presence of two eyes, placed anteriorly; it has a frontal circular rotatory organ, and a truncated bifid tail, or false foot. The alimentary canal is short, thick, and conical; it sometimes contains green matter. The two protruding forceps-like bodies, in the middle of the rotatory organ, may, says Dr. Ehrenberg, be considered teeth; pancreatic glands are indicated by knot-like turbid bodies. The eyes are sharply circumscribed, and situated at the frontal region; a respiratory tube unknown. Dujardin believes this genus based on young animals, and as such unsatisfactory.

Glenophora *trochus*.—Body ovato-conical, truncated, and turgid anteriorly, attenuated posteriorly into a false foot; the eyes are blackish. It swims quickly, like a *Trichodina* or free *Vorticella*. The genera *Monolabis* and *Microcodon* have similar forms. Figs. 359, 360, represent two animalcules, the latter having the stomach filled with a green substance. Size 1-570th.

Family.—OECISTINA.

Rotatoria with a single rotatory organ entire at the margin, with a gelatinous envelope or lorica. This family contains only two genera, which possess an organization more developed than any yet described. Locomotive organs, with internal muscles, (says Ehrenberg,) and a tail foot, not pincer-like, nutritive organs, with a chewing apparatus, consisting of teeth in rows, two pancreatic glands, as well as the development and expulsion of ova, are observed. Male organs, vessels, two filiform tremulous organs (gills), and nervous fibrillæ, along with ganglia, are elicited in *Conochilus*, and red visual spots in both genera. They are thus tabulated:

Lorica	special and distinct to each single animalcule................	Oecistes.
	conglomerate, or common to many single animalcules........	Conochilus.

Genus Oecistes.—*The sheathed little fish Animalcules* are characterised by each animalcule having a separate lorica. They have two eyes, situated anteriorly, which become effaced as age advances. A simple wreath of cilia is observed in the frontal region of the body; the long tail-like foot has internal longitudinal muscles. A simple tubular contracted alimentary canal, with an elongated stomach, teeth in rows, attached to two jaws, situated at the head or bulb of the œsophagus, and two pancreatic glands, compose the apparatus of nutrition. The visual organs are red when the animalcule is young, and colourless in old age. The ovarium has only a single ovum. The lorica is a viscid, gelatinous, cylindrical box (*urceolus*), into which the animalcule can entirely withdraw itself, or which it may quit when a new one is desirable.

The attachment to the bottom of the lorica is by the under surface of the end of the foot-like tail.

Oecistes *crystallinus.*—Lorica hyaline, viscid, floccose; body crystalline. The structure it is difficult to see. Each jaw has three distinct teeth. The development of the young from the egg is interesting to observe: Dr. Ehrenberg saw within the shell two dark points (eyes) near the already-developed jaws, and on giving the egg a gentle pressure it burst, and the free young animal came forth. Fig. 361 represents a full-grown animalcule in the act of unfolding itself; fig. 362 is another with its rotatory organ expanded. Their shells are incrusted, and within may be seen a number of eggs; figs. 363, 364, represent them attached to the pectinated leaves of the water-violet, as they appear under a shallow pocket magnifier. Length, with tail, 1-36th; without, 1-140th; lorica 1-70th.

Genus Conochilus.—*The lipped-top Animalcules* are social, having conglomerate and contiguous loricæ; each animalcule has two permanent eyes. Only one species is known; its description, therefore, will include that of the genus.

C. *volvox.*—The compound masses white; lorica gelatinous, hyaline, within which from ten to forty animalcules unite, and form a radiating sphere, that revolves in swimming, like the Volvox. The brow, or frontal region of the animalcule, is broad, truncated, and surrounded with a wreath of cilia, interrupted at the mouth, which is lateral. On the frontal plane arise four thick conical papillæ, often furnished with an articulated bristle, especially the two anterior, as seen in figs. 365, 366, and 368. The œsophagus is short and narrow, its head, or bulb, has jaws, with teeth, and four muscles; it lies immediately within the mouth. The stomach and rectum are oval. Two spherical, pancreatic, or salivary glands, are observed near the œsophagus, and posteriorly an ovarium, often containing a large ovum, which is expelled near the base of the tail. The ovate or shortly-cylindrical body terminates in a long, thin, and strong cylindrical foot-like tail, the end having a suction disc. The gelatinous lorica, is only perceptible in coloured water, except when infested with green parasitical Monads; within it the animalcules can completely withdraw themselves, their tails becoming thickened and bent. (In the group, figs. 365 to 368, the lorica is

not shown.) There are no anterior muscles, but three pairs of posterior ones, which disappear near the rotatory organ; there is also a back and two lateral pairs. Several transverse vessels appear connected with two anterior, lateral, longitudinal vessels, which, Dr. Ehrenberg states, must arise from a vascular network near the head, as in *Hydatina.* He has also seen two spiral bands (gills), situated posteriorly. Two beautiful red vi·ual organs lie immediately beneath the wreath of cilia, and behind them little oval nervous ganglia. In the foot-like tail are two large wedge-shaped glands, probably male organs. These creatures will feed upon carmine and indigo, but are mostly filled with a golden-coloured food. Fig. 370 represents a cluster of animalcules magnified about ten diameters, of which figs. 365 to 368 represent a portion, highly magnified; the first is an under view, the two next dorsal views, and the last a side view. Fig. 369 shows the jaws, teeth, and part of the œsophagus-bulb separate. Size 1-60th; sphere 1-9th.

Family.—MEGALOTROCHAEA.

No envelope or lorica; rotatory organ simple, incised, or flexuose at the margin; it constitutes the purveying and locomotive apparatus. Distinct muscular bands are seen, which can change the shape of the body. In *Megalotrocha,* the alimentary canal is provided with two jaws, a stomach, two cœca, and two pancreatic glands. In the other genera, it is a simple canal, without stomach and cœca; *Microcodon* has two single-toothed jaws, but no pancreatic glands; and *Cyphonautes* is toothless. The ovarium in all the genera developes a few large ova. In *Megalotrocha,* the ovum is attached to a thread; vessels and tremulous gills are observed in that genus; organs of sensation are indicated by the red eyes in two genera; in the third, a ganglion is seen in their place. In *Megalotrocha* radiating nervous ganglia, analogous to a brain, and four dark glandular spheres, in the neighbourhood of the mouth are seen.

The genera are thus related:

Eyes absent		Cyphonautes.
Eyes present	one eye	Microcodon.
	two eyes	Megalotrocha.

These genera are undescribed by Dujardin, *Cyphonautes* he considers a doubtful member of the *Rotatoria,* and would transfer *Microcodon* to another family, its caudal process being rather an articulated flexible tail than a contractile pedicle. Only *Megalotrocha* is admitted by Siebold.

Genus CYPHONAUTES. *The hump-backed Animalcules* are destitute of eyes. Locomotion is performed by the continuous but notched cilia wreath and internal band-like muscles. The nutritive apparatus consists of a toothless œsophagus, an alimentary canal, with probably a pancreatic gland; an ovarium, with a single large ovum is visible; vessels and tremulous gills unknown; a nervous system is indicated by a round glandular knot at the œsophagus.

C. *compressus.*—Body white, compressed, obtusely triangular, truncated anteriorly, and sub-acutely gibbous upon the back; near the œsophageal head is a spherical gland, probably a brain; no eye with coloured pigment is present; on each side a band-like muscle proceeds to the end of the back, which terminates in a changeable tuberosity (perhaps suction disc). It swims with a vacillating motion. Fig. 373, P. 8, represents a full-grown animalcule. Found in sea water. Size 1-100th.

Genus MICROCODON. *The bell little fish Animalcules.*—Eye single; wreath of cilia simple, bent in the middle, so as to resemble the figure 8 lying transversely; alimentary canal thick and straight, without a stomach; no œsophageal tube, but a sort of œsophageal bulb and a couple of single-toothed jaws; also a turbid ovarium. Immediately behind the rotatory apparatus is a small red visual organ, and at the frontal region beside it is a reddish knot whose function is unknown.

M. *clavus.*—Body campanulate, pedicled, the styliform foot-like tail as long as the body; in the middle of the brow are two bundles of stiff bristles, two pincer-like points, evidently teeth, project out of the middle of the rotatory organ, and are in connection with the reddish jaws. Fig. 371 is a back, and fig. 372 a left side view. Size 1-280th.

Genus MEGALOTROCHA. *The parasol or great wheeled Animalcules.*—Eyes two, sometimes becoming effaced by age: rotatory

organ has two lappets. The nutritive system consists of a stomach, cæcum, rectum, and œsophageal head, having two jaws, with teeth, and two pancreatic glands; reproductive organs, a short knotted ovarium, with a few ova; muscles, three pair anterior, two pair posterior, longitudinal; two contractile muscles for the rotatory organ, and four œsophageal. The eyes are frontal, of a red colour when young; two, many-partite, radiant nervous masses are distributed in the disc of the rotatory organ; these represent the nervous structures and organs of sensation, four circular transverse-lying vessels (muscles?) are also seen. The nature of the four opaque white spherical bodies at the base of the rotatory organ is unknown.

MEGALOTROCHA *albo-flavicans* (*Vorticella socialis*, M.)—White and free, when young; yellowish, and attached in radiating clusters, when old. Ehrenberg states he has often perceived the red eyes within the unbroken egg, and the jaws, as if in the act of chewing, move laterally and horizontally against each other. Two ova are rarely produced at one time; the egg, when expelled from the body, remains attached to it by a thread, and the parent has often four or five thus attached, and in process of further development. Ehrenberg's observations on the embryo are highly interesting: he says, "In the ovum, whilst within the ovarium, a bright germ makes its appearance as a round clear spot; within this a turbid nucleus developes itself, which at first is surrounded with a bright broad margin of fluidity; within the nucleus a central pellucid vesicle, like a yolk, is gradually developed; the ovum is then expelled. The embryo is now quickly developed within the vesicle of the nucleus or yolk, and becomes visible when this latter is consumed; a turbid central spot then appears, which becomes the œsophageal bulb and teeth; a blackish granular oval body is also seen posteriorly, the eyes gradually become red, and a motion of the cilia is visible: after some hours the whole fœtus, which is folded up, turns itself round, the shell bursts, and the young animalcule creeps out; it then fixes itself between the older ones, but in a little time the young creature detaches itself and swims about as a rolling sphere, and at the expiration of a certain period attaches itself to some firm body." Figs. 374 to 376 represent different specimens; fig. 377 merely the teeth and jaws separate. Found

upon water plants. Size of single animalcule 1-36th; of the spheres 1-6th. (P. 23, Fig. 1.)

MEGALOTROCHA *velata* (Gosse).—Animals separate; disc partially enveloped in a cleft granular integument; eggs not attached to the parent after deposition. Length 1-55th.

FAMILY.—FLOSCULARIA.

Rotatoria enveloped in a case, and provided with a single rotatory organ, flexuose at the margin, and lobed or divided, with from two to six clefts; when the latter number, it appears compound. The cilia of this organ in some genera are quiescent, and only vibratile occasionally. The alimentary canal has toothed jaws, and generally a stomach; the genus *Lacinularia* only has cæcal appendages to the latter, but in all of them oval or semi-spherical pancreatic glands are seen. The reproductive organs are, a short ovarium, in which only a few ova are developed at a time, and in *Lacinularia*, *Melicerta*, and perhaps in *Floscularia* and *Stephanoceros*, male glands. In *Lacinularia* four transverse circular vessels, and a strong vascular network at the base of the rotatory organ, are seen; internal tremulous gill-like organs in *Lacinularia* and *Stephanoceros* only; eyes are distinct in all, except *Tubicolaria*. In *Lacinularia*, *Limnias*, and *Melicerta*, brain and masses of nervous matter are seen. Touching their muscular structure, two pairs of muscles seemingly contract the body posteriorly; the rotatory organs of *Lacinularia* and *Melicerta* have special ones. The evolution of young in the ovum takes place as in Hydatina.

The family is disposed in genera, thus:

Eyes absent			Tubicolaria.
One eye present (when young)			Stephanoceros.
Two eyes present (when young.)	rotatory organ two-parted when full-grown	envelope of the single animalcules distinct or separated	Limnias.
		envelope of the single animalcules conglomerated.	Lacinularia.
	rotatory organ four-parted when full-grown		Melicerta.
	rotatory organ five to six-parted when full-grown		Floscularia.

Dujardin has a family *Flosculariens*, which, however, differs much

in the characters assigned it, and in the species included in it from the *Floscularia* of Ehrenberg. Only two genera are placed by the French naturalist in his family: viz. *Floscularia* and *Stephanoceros.* Contrary to Ehrenberg's assertion, those two genera are stated by Dujardin to be destitute of a rotatory organ—indeed, of *vibratile* cilia; and are described as having a campanulate, contractile body, tapering towards the base so as to form a long pedicle, by which they are affixed to solid bodies. The mouth furnished with horny jaws. Speaking of their affinities, he remarks, "The *Flosculariens,* like the *Melicerticus* also, have a certain affinity in form with the *Vorticelliens* and the *Stentors,* and also with the *Campanularia* among *Polypes;* they live in the same way, fixed to water plants by the pedicle of their campanulate body, the margin of which presents five or six lobes, terminated by appendages or cilia, without, however, indication of a vibratile movement. At the bottom of this wide opening is situated the mouth, provided with jaws attached to a muscular bulb, less frequent and regular in its movements than the like organ in other *Rotatoria.* In *Floscularia* the jaws are simple, and the lobes of the (anterior) margin short, but with long radiating cilia; whilst in *Stephanoceros* the jaws are compound, and the marginal lobes very long and covered with short cilia."

Dujardin states further, that the gelatinous case of *Floscularia* may disappear, and therefore cannot be used as a generic distinction, either in the case of that genus, or indeed of the other genera included in Ehrenberg's family of that name. Entertaining this opinion of the differences of the gelatinous envelope being accidental, not constant, Dujardin rejects the genus *Limnias* as not distinct from *Lacinularia.* Of the remaining examples of Ehrenberg's family *Floscularia,* viz. *Tubicolaria, Lacinularia,* and *Melicerta,* with *Ptygura,* previously described, Dujardin constitutes a family he calls *Melicertiens.*

Genus Tubicolaria.—*The encased wheel Animalcules* are destitute of eyes at all ages (?), have a four-lobed rotatory organ, and a transparent gelatinous case (*urceolus*). Internally are four posterior longitudinal muscles, an alimentary canal, with a long stomach, devoid of cæcal appendages; a short rectum, an œsophageal head

with four muscles; two jaws with teeth; two semi-spherical pancreatic glands; and an ovarium, with a single ovum; anteriorly, upon the ventral surface, are two respiratory tubes.

TUBICOLARIA *najas*.—The jaws have four teeth, and the respiratory tubes are hairy anteriorly. It is described fully in the account of the genus, and figs. 379 to 382 will illustrate it; 381 represents the animals of natural size, as found attached to the roots of Lemna polyrhiza, with those of the following genus; 379 represents an animalcule within its case, the rotatory organ withdrawn; 380, another animalcule extended, and without its lorica. Fig. 382 shows the œsophagus, with the jaws and teeth separate. Length 1-36th.

Genus STEPHANOCEROS.—*The crown-wheel Animalcules* have one eye, and a rotatory organ, deeply divided into lobes, and furnished with verticellate cilia: this organ performs the office of locomotion. Alimentary canal simple, with a stomach and small rectum; the œsophageal head has jaws, with four teeth; before it is a large crop-like structure, and two glands at the stomach; the ovarium developes only a few ova at a time; perhaps two male glands exist at the commencement of the row of tremulous gills; a red visual point, with a row of nervous ganglia, in pairs, are visible at the base of the rotatory organ; young animalcules possess a small glandular dark body internally.

S. *Eickhornii*.—The case transparent, like glass; rotatory organ has five lobes or arms, each furnished with fifteen verticellate cilia; these arms act as a prehensile instrument occasionally, and are spread out, as shown in the engraving, fig. 383, which represents a full-grown animalcule, with four ova within it; two have the young developed, which are only expelled when in this state; hence Ehrenberg considers this creature viviparous. In this figure the eye and gills are visible, and over the latter the ganglia. The case is difficult to be discerned under the microscope, from its very transparent nature, unless indigo is mixed with the water. Length 1-36th.

Genus LIMNIAS.—Eyes two; case (*urceolus*) solitary; rotatory organ two-lobed when full-grown, being then constricted in the middle; alimentary canal simple, terminating at the base of the tail;

stomach, two jaws with teeth, and two pancreatic glands, also present. The ova are deposited within the case, and there developed; neither male organs, gills, nor vessels discovered; two visual organs indicate a system of sensation; these, in the young animalcules, are red, and are even visible within the ovum, but in old age the colour disappears, and hence they are not seen; in the middle of the rotatory organ, when expanded, are seen four large globules, which Dr. Ehrenberg considers nervous ganglia, or brain.

LIMNIAS *ceratophylli.*—Case white at first, afterwards brown, or blackish; smooth, but being viscid, often covered with extraneous particles; its connection with the animalcule is a voluntary act of the latter; the two red eyes and the jaws may be observed in the ova, when developed; by giving the latter a gentle pressure, the shell bursts. Fig. 389 exhibits an animalcule just emerged from the egg, 392; fig. 391 is a young specimen, with the rotatory organ nearly circular; it also shows the two eyes. Fig. 390 is a full-grown specimen, without its case, fed on indigo, the jaws (each of which has three strong teeth), the ova, and traces of two (four ?) longitudinal muscles, are seen: the wheel is folded up. Fig. 388 is another within its case, having the lobed rotatory organ expanded. (P. 23, fig. 2, more magnified.) Found upon hornwort (Ceratophyllum), and other aquatic plants. Length about 1-20th; case 1-40th.

L. ——— ? appears to be a distinct species which I do not find described. The case is ribbed and semi-transparent, and is composed of a series of lateral rings. Found in a ditch near Witlingham, Norwich, on duck-weed, (Brightwell.)

Genus LACINULARIA.—*The horse-shoe Animalcules* have two eyes (in the young state); the cases (*urceoli*) conglomerate, or grown together; rotatory organ two-lobed, when full-grown, but circular when young; this organ is the chief instrument of locomotion: band-like longitudinal muscles run within the body. Œsophageal head large, with two jaws, and teeth in rows; œsophagus short, narrow; stomach elongated, but with no cæca-like appendages; pancreatic glands two, ovate; rectum short, globose. The ovarium is situate about the middle of the body, and contains but a few large ova; four fecundating glands appear below the discharging orifice,

which latter is common to the ovarium and alimentary canal; transverse circular canals, vascular network at the base of the rotatory organs, and tremulous gill-like bodies, are observable. The system of sensation is indicated by the visual organs, which rest on ganglia; they are red in the developed ovum and young animalcule, but become blackish or disappear with age. Near the œsophagus is situated a nervous mass (analogous to brain), divided into four or six lobes; also (as in *Megalotrocha*) two ring-like radiant processes with a row of ganglia, these lie beneath the muscles of the cilia wreath; the longest lobes (ganglia) are seen from the ventral surface.

Lacinularia *socialis* (*Vorticella socialis et flosculosa,* M.)—Lorica gelatinous, of a yellowish colour, and conglomerate, several (from ten to sixty) uniting to form a spherical mass. Each animalcule is fixed by its tail to a separate cell, within which it can entirely withdraw itself. It has a large horseshoe-shaped rotatory organ; seven or eight eggs are deposited, free, within each cell; the young, when hatched, form a new cluster, swim away, and form loricæ; when only one is born, it attaches itself at the side of the parent. In a recent paper by Mr. Howard on this species, he states there are two kinds of reproductive bodies, one the ordinary ova, the others twice their size representing gemmae. Fig. 378 is an animalcule separated from the mass; it is highly magnified, and exhibits the organization described under its genus. Found on Chara and other aquatic plants near the margin of rivers. Length 1-36th.

Genus Melicerta.—*The four-leaved Animalcules;* eyes two (at least when young); cases solitary; rotatory organ single, with four lobes, when expanded. It has free longitudinal muscles for the contraction of the body; alimentary canal broad and simple, with a stomach-like division; its œsophageal head has four muscles, two jaws, with teeth in rows, and two pancreatic glands; the mouth is situated under the large leaves or lobes of the rotatory organ; the discharging orifice is at the base of the prehensile tail: in its propagative system it resembles the preceding genus, but the male portion is not satisfactorily known. A vascular system not observed, but the two tubular processes beneath the mouth are probably subservient to respiration; the two frontal eyes in the ova and young

animalcules, together with the curved glandular band of nervous matter in each leaflet of the vibratile organ, represent the system of sensation; the chewing movement of the mouth has been often mistaken for the action of a heart.

MELICERTA *ringens.*—Case conical, granulated, resembling a honey-comb of a brownish-red colour; it is composed of small lenticular bodies, expressly deposited by the animalcule from the posterior alimentary opening, (and not foreign matter, like the habitations of the larvæ of the Phryganea;) these are agglutinated by a peculiar viscid matter, also exuded, and afterwards hardened in the water. Into this tube the soft crystalline or whitish animalcule can withdraw itself; when its flower-like wheelwork is expanded, the vibratile cilia appear to run along the margin of this organ, but, in fact, each single cilium only turns itself upon its base, and the aggregate motion causes a little whirlpool in the water, directed towards the mouth, situated in the middle of the two large leaflets of this organ; the eyes are placed near the two other bent leaflets, which, according to Dr. Ehrenberg, are analogous to a cleft upper lip of the dorsal surface; the discharging orifice is on the same side, and therefore the dorsal tail-like portion becomes a ventral member, or foot. Fig. 386 exhibits an animalcule within its case, and having the rotatory organ contracted: fig. 387 is another, with the latter fully expanded; in this drawing, an outline only of the case is given, in order to show the internal structure. Two of the ova exhibit the eyes and teeth, the latter are formed first. (P. 23, fig. 1.) Found upon Lemna and other aquatic plants. Length 1-12th; case 1-24th; egg 1-150th.

"The case of *M. ringens* is formed of lenticular particles of reddish-brown matter, thrown up by the animal from its discharging orifice (which is at the upper part), and glued together by it in lateral rows. This curious process may be detected on a careful patient observation, and the animal may be made to build a coloured case by mixing carmine or indigo with the water; or a case composed of alternate rows of blue and red, if the colours are carefully changed." (Brightwell.)

That the coloured pellets of the outer case are extended from the

intestinal outlet, as above supposed, appears, from the careful researches of Mr. Gosse, to be an error, (Trans. Micros. Soc., vol. iii, part ii, 1851, p. 62.) That observer points out the existence of a special rotating organ of a cup-like figure, seated immediately above the projecting tube. (P. 23, fig. 1, the disc seen above, b.) This organ he saw fill and empty itself "many times in succession, until a goodly array of dark pellets were laid" down irregularly; the animal effecting their distribution by bending downward its head, so as to bring this cup and the margin of its sheath into apposition. "After a certain number were deposited in one part, the animal would suddenly turn itself round in its case, and deposit some in another part. It took from two and a half to three and a half minutes to make and deposit a pellet" Coloured particles in the water "are hurled round the margin of the ciliated disc, until they pass off in front through the great sinus between the large petals:" and the atoms, if few, "glide along the facial surface, following the irregularities of the outline with great precision, dash round the projecting chin, and lodge themselves one after another in the little cup-like receptacle beneath," in which again they are whorled round with great rapidity, and prepared into pellets for the building up of the case of the animal.

Genus Floscularia.—*The flower-wheel Animalcules* possess (when young at least) two eyes, and a rotatory organ, four or five (?) or more lobed. These elegant animalcules have each a distinct gelatinous case, attached to water plants. They are often so very diaphanous as to escape observation, unless the water is rendered turbid with colour; the rotatory organ is so very peculiar in structure that some observers do not consider it as such. The alimentary canal is simple and conical (Coelogastrica), but is remarkable as possessing a second œsophageal bulb or head, the lower one only having jaws and teeth; two pancreatic glands are present anteriorly. The propagative system resembles that of *Lacinularia*. The ova are deposited in the case; vessels unknown. The red eyes indicate sensation. They somewhat resemble in appearance *Acineta*.

F. *proboscidea*.—Case cylindrical, hyaline, gelatinous; rotatory organ six-lobed, with short cilia surrounding a ciliated flexible

proboscis, which has apparently an opening at its end. Dujardin thinks this proboscis may be nothing more than one of the ciliated lobes advanced towards the centre. Body ovate; has a long styliform contractile foot-like tail attached to the base of its case; when extended, the body and part of this foot are protruded. Found upon the leaves of Hottonia palustris. Length, when extended, 1-18th; case 1-36th.

FLOSCULARIA *ornata* (*Cercaria*, M.)—Case hyaline, rotatory organ five or six-lobed, no proboscis. It is sluggish and unfolds itself slowly, but often contracts quickly within its case. The end of each lobe of the rotatory organ is thickened, and has from five to eight very long cilia generally stretched stiffly out. They are very fond of *Chlamidomonas*, and in swallowing large bodies, as *Naviculæ*, contract the whole body. Ehrenberg has numbered as many as five ova in the case at one time: some were generally quite developed, showing the movement of the young, with the two red eyes. Under a moderate pressure the shell burst, and the young animalcule crawled out, slightly vibrating; the cilia were short and not very distinct, but the œsophageal head was in action. When old the foot-tail is truncated. Found upon *Ceratophyllum*. Size of body 1-108th.

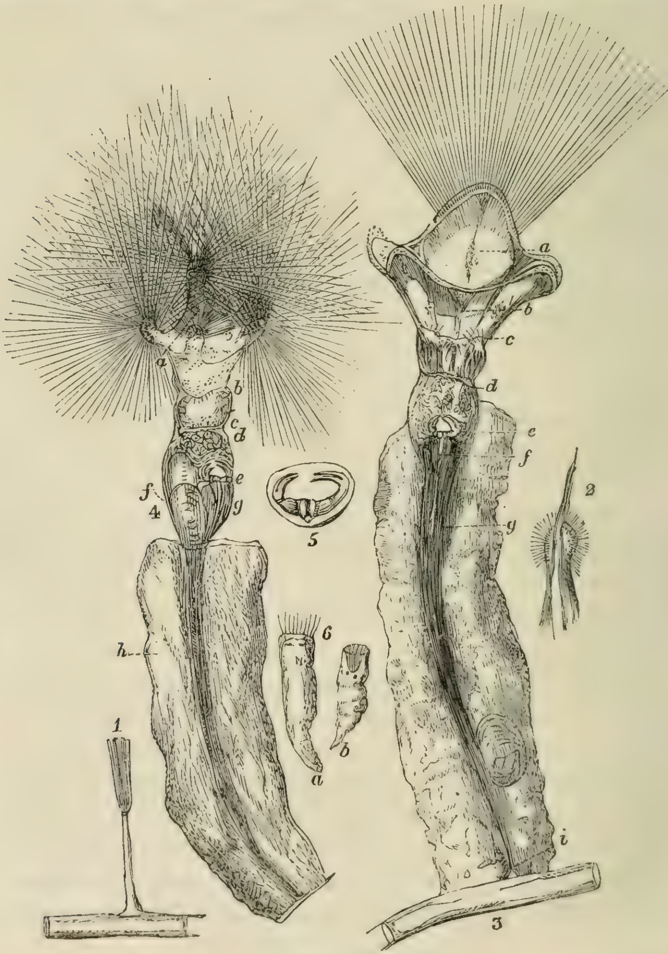
Dr. Dobie writes ('Annals of Nat. Hist.,' October, 1849,) "Ehrenberg regards the *Floscularia*, described and figured by M. Peltier, as identical with his F. *ornata*. Both Dujardin and Peltier found the rotatory organ five-lobed in the species observed in France, so we must either hold with Pritchard, that F. *ornata* has sometimes five, at others six lobes, or consider the five-lobed species a variety of F. *ornata*. . . . My friend Mr. Hallett writes me that he finds F. *ornata* with a six-lobed rotatory organ and no process."

The two next species and accompanying remarks are taken from a paper by Dr. W. M. Dobie, ('Annals of Nat. Hist.,' October, 1849.)

F. *campanulata*.—Case diaphanous, rotatory organ with five flattened lobes, fringed with very long cilia; body ovate, without proboscis; tail long and terminating abruptly in a transparent filament, spread out in a kind of sucker at the point of attachment. Length 1-50th when extended. Egg with two red eye spots, con-

tained in a large ovary. Found near Chester on Ceratophyllum and Conferva.

FLOSCULARIA *cornuta.*—Case short, diaphanous, not very distinct; rotatory organ furnished with five rounded lobes, surrounded with extremely long and delicate cilia; a short, narrow, non-ciliated, flexible process (cornu) is attached to the outside of one of the lobes. Egg with two red eye spots; young animal with vibratile cilia on the head, and rapidly locomotive. Length 1-40th when extended. In same locality as the preceding. (See wood-cuts.)



Floscularia cornuta, Dobie.

The lobes of the rotatory organ of F. *cornuta* resemble very much those of F. *ornata :* only five exist, while in the other there are six, according to Ehrenberg. The F. *campanulata* is gregarious, but F. *cornuta* solitary; and the former, too, is stronger and more active than the latter.

FAMILY.—HYDATINAEA.

The members of this highly-organized and extensive family of rotatory animalcules are destitute of lorica; their wheel-like apparatus is divided into several distinct lobes or parts, always more than two in number. The compound state of this organ is best expressed by saying that it is not a mere circular or semi-circular row of cilia, but several groups, completely separated from each other, and situated on the anterior part of these soft-bodied animalcules. All the genera, *Polyarthra* excepted, have a tail-like foot, or a styliform or pincer-formed process on the abdominal surface—hence not properly a tail, that member being always a prolongation of the dorsal surface. In several of the genera, the muscles for altering the form of the body are distinct. The nutritive system is completely elicited in all; it consists mostly of a simple conical alimentary canal, without a stomach-like division (Coelogastrica); but *Diglena catellina, Polyarthra,* and *Triarthra longiseta,* have true constricted stomachs. *Enteroplea, Notommata myrmeleo,* N. *syrinx,* N. *clavulata,* the *Synchaetae,* and *Diglena lacustris,* have a long œsophagus or stomach, and a suddenly-attenuated discharging canal (Gasterodela). *Enteroplea* alone has radiant vessels at the œsophagus. *Notommata clavulata* and *Diglena lacustris* have special cæca at the stomach. *Enteroplea* is the only genus destitute of teeth, though their presence is doubtful in *Rattulus.* Pancreatic glands, under different modifications, are present in all the genera. The propagative system is distinctly hermaphroditic in fifteen genera. The ovarium, which only evolves a few large ova at a time, is mostly ovate: in *Notommata myrmeleo,* in N. *clavulata,* and so also in *Diglena lacustris,* it is very long. It communicates, by a short oviduct, with the alimentary canal near its termination. None of the species are viviparous. There are two filiform, extended, wedge-

shaped glands, and a contractile vesicle. The egg is worthy of notice, having sometimes a smooth soft shell, at others a hard spinous one; the latter is termed the winter ovum, and considered by M. Turpin as constituting the genera Bursella and Erithrinella (?) of plants. In eleven genera, a vascular system, composed of transverse and longitudinal vessels, a cervical net-work and free tremulous organs, like gills, with respiratory tubes or openings in the neck, are observed. The system of sensation is indicated by the presence of eyes, mostly red, with a ganglion beneath them; these organs, seated anteriorly upon the edge of the upper surface of the body, or in the neck opposite to the mouth, indicate the back or dorsal surface of the animalcule. Nerve-like fibrillæ also exist in several species of *Notommata*, *Diglena*, *Enteroplea*, *Triarthra*, and especially in *Hydatina*. Some species of *Synchaeta* evolve light and give rise to the phosphorescence of the sea. *Hydatina senta*, *Diglena catellina*, and *Triarthra*, are sometimes so numerous as to render the pools of water in which they reside milky and turbid.

The genera are related as follow:—

Eyes absent	teeth absent				Enteroplea.
	teeth present	jaw many-toothed			Hydatina.
		jaw single-toothed			Pleurotrocha.
Eyes present	one	frontal			Furcularia.
		cervical	foot styliform		Monocerca.
			foot furcated	front cilia, no uncini or styles	Notommata.
				frontal cilia and styles	Synchaeta.
				frontal cilia and uncini	Scaridium.
			no foot, but a many partile beard, or fins		Polyarthra.
	two	frontal	foot furcated		Diglena.
			foot styliform	beard	Triarthra.
				no beard	Rattulus.
		cervical; foot furcated			Distemma.
	three	non-pedicelled	cervical		Triophthalmus.
			two frontal, one cervical		Eosphora.
		two pedicelled frontal eyes, one non-pedicelled cervical eye			Otoglena.
	with many simply conglomerate eyes, more than three				Cycloglena.
	with many doubly-conglomerate eyes, more than three				Theorus.

Besides the two families of *Rotatoria*, *Flosculariens*, and *Melicertiens*, constituted by M. Dujardin, he makes but four others, and one of these, "*Albertiens*," represented by a single genus peculiar to his work. These four families are "*Brachioniens*," "*Furculariens*," "*Albertiens*," and "*Rotifera*." The family *Rotifera* comprises but two genera, *Rotifer* and *Callidina*, consequently all the genera of Ehrenberg yet undescribed, and which are admitted by Dujardin, fall under the two families *Brachioniens* and *Furculariens*. Excepting two genera, the last named family includes several of Ehrenberg's *Hydatinaea*, whilst the other family *Brachioniens* is represented by examples taken from the families *Brachionaea*, *Euchlanidota*, and *Hydatinaea*, of Ehrenberg's arrangement.

The great differences of classification adopted by the two naturalists referred to, are traceable to the different systematic value assigned by each to particular parts or organs, and especially to the eye specks, the use of which in framing distinctions is entirely ignored by Dujardin.

Genus Enteroplea.—Without eyes or teeth; foot fork-like; the cilia of the vibratile organ disposed in bundles, implanted in semiglobular muscles. Several longitudinal muscles move the body, others the foot-like pincers. Œsophagus long, with a bulb or head surrounded by a radiant (vascular?) wreath; alimentary canal conical anteriorly, with two ear-like pancreatic glands; posteriorly it suddenly diminishes, and terminates where the muscles of the foot commence. The propagative structures are a large ovarium, two thin wedge-shaped glands, and a contractile vesicle. The vascular system is indicated by many parallel transverse circular canals, and a large tremulous organ, similar to a gill, near the contractile vesicle. A brain-like knot, situated near the œsophagus, sends off a thick tortuous thread along the dorsal surface to the second transverse vessel, where the respiratory opening probably exists. Posteriorly, near the alimentary canal, is a dark granular organ, whose function is unknown.

E. *hyalina.*—Body conical, transparent, with a little forked foot. Anteriorly, four longitudinal muscles reach to the middle of the body, and one dorsal, one ventral, and two opposed lateral ones, are also seen. Two internal short wedge-shaped muscles move the

pincer-like foot. Ehrenberg counted ten or eleven circular canals. This animalcule is always smaller than *Hydatina senta,* which it greatly resembles. Fig. 393 represents this animalcule, in which the internal parts, named in the generic description, are shown. Length 1-120th.

Genus Hydatina.—*The crystal Animalcules* are destitute of eyes, but have two many-toothed jaws (fig. 383*) and a fork-like foot; locomotion is effected by the compound wheel organ, the pincer-like foot, and internal muscles; the last are most numerous in H. *senta.* The alimentary canal has a globose œsophageal head, with four muscles and jaws, and with two to five teeth. In H. *senta* the jaws are connected by a short œsophagus to a simple conical alimentary canal; in the other species, to a constricted one. The large anterior extremity? of the canal has two spherical glands. The ovarium is globular. Two thin wedge-shaped glands open into a contractile vesicle. The vascular system and gills are observed in H. *senta.* In both species the central ganglia, with cervical threads or loops, are visible.

H. *senta* (*Vorticella senta,* M.)—Body conical, hyaline; margin of the rotatory organ ciliated; foot truncate and robust. The vibratile organ, when extended, is always in motion; it consists of a simple external wreath of cilia somewhat interrupted at the mouth, and eleven internal bundles of cilia each enveloped in a muscular sheath. The body has nine muscular bands, situated thus:—one upper or anterior dorsal muscle (no under or posterior one), two anterior ventral, and two posterior ones closing thereon; one right, and one left anterior lateral, with posterior ones in continuation. The five anterior muscles arise between the muscular bundles of the rotatory organ, mostly at the margin; the dorsal ones arise from the centre, near the central ganglion, and are collectively attached to the internal skin of the abdomen, between the fourth and fifth transverse bands, their inserted extremities being enlarged. Here the four posterior muscles arise, and are inserted where the pincer-like foot projects; two longitudinally-striated muscular sheaths encase the inner root of the divided foot; and there is a sphincter to the anal opening. The fibrous structure of the band-like longitudinal muscles, as sometimes also transverse corrugations of the

fibres, are as distinct as in the larger animals. During the contraction of the body, they become shorter and broader, by which they are easily distinguished from the other band-like and filiform organs, which only become curved during contraction of the body (maintaining themselves passive). The alimentary canal has no true stomach ; it diminishes posteriorly, and the internal surface is provided with delicate vibratile cilia; it sometimes appears grape-like, which form little lateral pockets or stomachs: the ova often occupy a large portion of the body. In most cases, the creature fixes itself to a spot by its foot, and lays several eggs upon the same place, one after another, by a sudden contraction ; sometimes, when it is going to lay more eggs, it returns to the original spot. In eleven hours after the eggs were laid, vibration of the anterior cilia was observed, by Ehrenberg, within them; and in twenty-four hours the young escaped from the shell. Many of the ova have a double shell, and leave a bright space between the two at one of the extremities; similar ova are found in other Rotatoria, having different shapes. In these double shelled ova the young are slowly developed. Ehrenberg names them "lasting eggs, or winter eggs." Some eggs are covered with Hygrocrocis, and appear quite hairy; these have been regarded as the normal state of other ciliated animalcules. Two kinds of disease destroy the *Hydatina,* and most of the Rotatoria: 1st, the formation of vesicles, or little bladders, which give rise to the appearance of small rings all over the creature; 2nd, the formation of granules, from which all the internal organs appear as if composed of delicate granules and shagreened ; 3rd, the overgrowth of Algæ upon their bodies. Foul water likewise kills them. Fig. 394 represents a vibratile animalcule completely unfolded, seen from the ventral surface. The arrows in the alimentary canal indicate a decussating, or circulating movement of its contents, produced by delicate internal cilia, and must not be mistaken for the motion of Monads.

HYDATINA *brachydactyla.*—Body cylindrical, truncated anteriorly, and suddenly attenuated at the base of the foot; claws short. Found on Hottonia, &c. Length 1-144th. Dujardin would include in this genus *Hydatina* several Rotatoria distributed by Ehrenberg among other genera. He says: "Notwithstanding the presence

of a red eye speck, we must consider as *Hydatinae,*—1. *Notommata tuba;* 2. N. *brachionus;* 3. N. *tripus;* N. *clavulata,*" and, though doubtfully, N. *saccigera,* for this species in form resembles a true Furcularia. "The *Synchoetoe* (Ehr.) characterized by their stiff setae or styles, are true *Hydatina* from their conical or campanulate form, if their jaws are really pectinated, but if not they will constitute a genus apart." . . . "The *Distemna maximum,* represented by Ehrenberg with pectinated jaws, and placed as doubtful by him in the genus *Distemma,* characterized by a double eye speck, appears to be a true *Hydatina.*"

Genus Pleurotrocha.— *The awl-shaped tooth Rotatoria* have no eyes, but possess a single tooth in each jaw, and a furcate foot. The rotatory organ consists, not of a simple wreath of cilia, but of cilia distributed in bundles near each other, the bundles being placed in muscular cases. In P. *gibba* there are two muscles for moving the foot, and in all the species the œsophageal head has four. This head is globular; it has two single-toothed jaws (fig. 396); these, and the short œsophagus, the simple conical alimentary canal, having anteriorly two spherical pancreatic glands, constitute the nutritive apparatus. The posterior opening of the canal is at the base of the foot, upon the dorsal surface. The propagative system consists of a globular ovarium. In P. *leptura* a contractile vesicle is seen. Organs of sensation are not satisfactorily known, and the nervous loop in the neck of the *Hydatina* appears wanting in this genus. This genus is not admitted by Dujardin.

P. *gibba.*—Body truncated anteriorly, enlarging from the front towards the base of the foot, where it is suddenly attenuated, the toes, or claws, short and turgid; near the mouth is a beak-like projection, forming an under lip. Fig. 395 is a right side view, and fig. 396 the teeth and œsophageal head dissected out. Found with *Hydatina brachydactyla.* Length 1-216th.

P. *constricta.*—Body elongated, conical, and separated from the head by a stricture; front oblique, toes straight and slender. This animalcule is very active and powerful. Found upon Ceratophyllum. Length 1-144th.

P. *leptura.*—Body turgid in the centre, front oblique, foot

slender, toes thin and slightly curved. Found amongst Conferva. Length 1-144th.

PLEUROTROCHA *renalis* (Ehr.) — Body elongate, slightly constricted in front, toes short, frontal portion rather oblique, truncate, pancreatic glands kidney-shaped (reniform). Length 1-240th. Berlin.

P. *truncata* (Gosse.)—Body sub-cylindrical; truncate behind above the foot; toes short, straight, slender. Length 1-175th.

Genus FURCULARIA.—*The forked-fish Rotatoria* have a single frontal eye, and a forked foot. Rotatory organ compound. Longitudinal muscles exist in F. *gibba*, and foot muscles in three species. The œsophagus is very short, its head has two jaws, single toothed (*monogomphia*) in two species, but not in the others; a simple conical alimentary canal (*coelogastrica*), with two ear-like glands, exists in all the species, and a distinct ovarium, except in F. *gibba*, which has only a contractile vesicle. Vessels, respiratory tubes, gills, &c., are not recognizable. The eye in F. *Reinhardti* is placed upon a brain-like mass.

Dujardin has the following remarks on the Genus *Furcularia*: "The genus *Furcularia*, one of the most numerous, undoubtedly requires to be divided after new observations, but not according to the number and disposition of the red points, as has been done by Ehrenberg. This author has indeed distributed some Systolides, which appear to us to have the closest relations in form and mode of living, into eight genera," viz., *Pleurotrocha, Furcularia, Notommata, Scaridium, Diglena, Distemma, Eosphorus,* and *Theorus*, "but many of these are purely nominal, and require a rigid revision."

"The following are the principal species to be classed with certainty among the *Furcularia*: 1. F. *furcata* = *Diglena caudata* (Ehr.), *Diglena capitata*, and *Furcularia gracilis*. 2. F. *marina*, of the same size and form as the preceding, but marine, and distinguished further by the styles of its tail, which are twice as short, and by its three-toothed but acute jaws, resembling a hook. 3. F. *forcipata*, placed by Ehrenberg among the *Diglena*. 4. F. *grandis* = *Diglena grandis* (Ehr.) 5. F. *forficula*, with which must also be associated *Distemma forficula*. 6. F. *canicula*, which Ehrenberg with doubt refers to *Diglena? aurita*. 7. F. *najas*, to which belong

the various Systolides more or less like *Hydatina*, in their club-shaped form and articulated tail, such as *Notommata petromyzon*, N. *najas*, N. *gibba*, and probably also *Eosphora najas*, E. *dignitata*, and E. *elongata* (Ehr.) We moreover refer provisionally to the genus *Furcularia* several other Systolides considerably dissimilar in form, some being very long, with two very long styles, of which Ehrenberg makes his *Notommata longiseta*, and N. *oequalis*, and his genus *Scaridium;* whilst others have an ovoid, thick body, rounded posteriorly, truncate in front, and with a short oblique tail, which Ehrenberg calls *Notommata myrimeleo*, and N. *syrinx*.

All these *Furcularia* except F. *marina*, to which F. *Reinhardti* of Ehrenberg must probably be added, have been found in fresh water; but it is most likely the number of those living in the sea are much more numerous, and I have indeed myself met with three or four distinct species, which I have from want of time not yet described.

FURCULARIA *gibba*.—Body oblong, slightly compressed, under side flat, back convex, toes forked, long (styliform), equal to half the body; the eye is placed upon a nervous ganglion over the mouth, clearly, indicating the dorsal surface; the ovarium has, generally, one large and ripe ovum; the movement of this animalcule is somewhat slow. Found in green water, and amongst Conferva. Length 1-96th.

F. *Reinhardti*.—Body fusiform, truncated in front, foot elongated, cylindrical, and shortly furcate at the end; a slight stricture divides the body and head. P. 9, fig. 397, represents an animal extended, and fig. 398, another, contracted; the former is a side (right), the latter a back, view. Found as a parasite upon Monopyxis (Sertularia) geniculata, in sea water. Length 1-120th.

F. *forficula*.—Body cylindrical, obtusely pointed in front, rounded, and dentated at the base, on the upper side; the toes very long; the rotatory organ appears to have two frontal clusters of cilia near the eye, and a wheel-like bundle on each side. Length 1-144th.

F. *gracilis*.—Body slender, cylindrical, suddenly attenuated at the base of the furcate foot; toes straight, long, but shorter than half the body. The rotatory organ appears disposed on six muscular masses, between, and superior to which, is a longish central ganglion, with a red eye. In green water. Length 1-180th.

Furcularia *cocca* (Gosse).—Body cylindrical; eye wanting, or not discernible; toes slender, obtuse. Length, including toes, 1-135th. Leamington.

Genus Monocerca—*The filiform-tailed Rotatoria*, seated upon a ganglionic mass, eye single, situate in the neck, foot simple, styliform, resembling a tail. In two species the vibratile cilia are distributed into about six bundles, their bandlike longitudinal muscles, and those of the foot, producing locomotion; the sides of the œsophageal head are unequal, as also the two jaws, which have one or two teeth; the œsophageal tube is curved and long, and the simple alimentary canal conical, with two ear-like pancreatic glands anteriorly. An *ovarium* and a contractile vesicle are evident. In two species a projecting respiratory tube at the frontal region indicates the existence of the vascular system.

M. *rattus* (*Trichoda rattus*, M.)—Body ovate, oblong, truncated anteriorly, and unarmed; foot styliform, the length of the body. This creature swims slowly, in a stiff manner; when stationary, it throws the styliform foot backwards and forwards. The ovarium has a reddish colour; behind it lies a roundish contractile vesicle. The foot has a short base, with a cordate internal muscle, and four unequal bristles. Amongst Conferva, &c. Length 1-120th.

M. *bicornis*.—Body ovate, oblong, truncated in front, armed with two spines; foot styliform, a little shorter than the body; the oblique œsophageal head exhibits delicate transverse corrugations; it has a bent and a straight jaw, with probably three teeth in each. Fig. 399 represents an animalcule (right side); fig. 417 another, contracted, and having its rat-like tail bent. Length 1-72nd.

M. (?) *valga* (*Vorticella valga*, M.)—Body small, almost cubical, with distinct head, an elevation on the back, and a conical foot, unequally forked; the rotatory organ, during contraction, shows four muscular sheaths, and the distinct red eye is placed upon a less distinct ganglion; the œsophageal head is not evident. Length 1-288th.

M. *brachyura* (Gosse.)—Form that of M. *rattus*, but the foot short (one fourth of total length), slightly curved, and horizontally flattened; a large eye in the occiput, *and another small one in the breast*. Length, including foot, 1-135th.

MONOCERCA *porcellus.*—Body thick and plump; foot short, much curved and bent under the body, dilated, flattened horizontally, and carrying a smaller spine beneath it as in a sheath; front and chin each armed with a short sharp spine. Length, including foot, 1-110th.

M. *stylata.*—Body short, irregularly oval; foot a nearly straight spine, less than one third of total length; eye large, red, set like a wart on the back of the occipital sac; forehead conical, pointed. Length, including foot, 1-170th.

Genus NOTOMMATA.—*The neck-eyed Rotatoria* have a single eye upon the neck, a bisulcate foot, resembling a forked tail. The rotatory organ compound, its cilia forming in bundles on the frontal region; eight of the larger species have numerous muscles; eighteen or nineteen have two jaws, each furnished with a single tooth; in eight the jaws have many teeth; the œsophagus is mostly short, with a simple wide conical alimentary canal (*coelogastrica*); in N. *tuba* only is there a stomach-like division, with a constriction (*gasterodela*, *a*), and in N. *myrmeleo*, N. *syrinx*, and N. *clavulata*, there is also a stomach-like enlarged place, but no constriction (*gasterodela, b*); cæcal appendages are observed only in N. *clavulata*. The two earlike anterior appendages of the alimentary canal, regarded as pancreatic glands, exist in twenty-four species. The propagative system, says Ehrenberg, is hermaphroditic in sixteen species; in the others the ovarium only is seen; none are viviparous: N. *syrinx* alone was observed by Ehrenberg to contain fully developed ova. The vascular system is represented, in ten species, by delicate tubes, with flexible and tremulous gills; only three of the smaller species have gills: in N. *myrmeleo* and N. *syrinx*, a broad vascular network is distinct about the head: a prominent respiratory (?) tube in the neck is present in four or five species; in some others an opening alone is seen. The visual point is red, except in N. *felis*, where it is colourless; a ganglion is placed beneath the eye in twenty-six species. In N. *copeus* and N. *centrura*, the brain is three-lobed, and placed over the œsophageal head; in the rest it consists of one or more nervous ganglia, situated amongst the ciliary muscles of the frontal region; free nervous threads and ganglia are also observed in different species. This genus is especially remarkable for the parasitical habits of its members.

They live upon other Rotatoria, upon the Polygastric Infusoria, and even within the globular masses of *Volvox globator;* "but," says Ehrenberg, "not like a cuckoo's egg in a hedge-sparrow's nest, but like the bear and the bee-hive, or a bird's nest in a wasp's nest."

Dujardin has the following criticisms on this genus *Notommata*:—

"Five of the species appear to be *Hydatina:* nine others, more or less distinct, are, in our opinion, *Furcularia;* three others *Plagiognathi,* some are imperfectly known, and only six at most offer sufficiently precise characters to retain the name *Notommata.* Such are—1. N. *Copeus.* 2. N. *centrura.* 3. N. *brachyota.* 4. N. *collaris.* 5. N. *aurita,* and—6. N. *ansata.* To these species must be added a seventh, called by Ehrenberg *Cycloglena lupus* . . . and an eighth, which we distinguish as *Notommata vermicularis.*

(*a.*) *Sub-genus* LABIDODON.—*One tooth in each jaw.*

NOTOMMATA *myrmeleo.*—Body large, bell-shaped; foot short, lateral; teeth curved in a circular forceps-like manner. (See fig. 420.) There are two varieties: in the one (var. *a*), a long thin œsophagus, a globular thick stomach, and a long rectum, constitute the alimentary organs. Ehrenberg, by pressure, made an animalcule, whose dark stomach nearly filled the body, disgorge two large specimens of *Lynceus minutus* (described and figured in the *Microscopic Cabinet*); the animalcule afterwards vibrated away in a lively manner. No respiratory tubes exist, but five transverse vessels and four longitudinal ones (a pair uniting to each of the first two transverse ones,) represent a vascular system in this variety. In the other (var. *b.*) a distinct vascular net-work is seen at the head, but only four transverse vessels, and two longitudinal ones going to the first. The red eye is much larger in this variety. Fig. 418 represents a side view of the variety *b.*, in which the various parts of its organization are clearly seen, as also a small *Crustacean,* within its stomach. Fig. 420 shews the structure of the manducatory organs separated. Fig. 419 is the upper part of an animalcule (var. *a*), shewing the smaller eye, rotatory organs, teeth, and network. Found in clear water, in turf hollows. Length 1-40th.

N. *syrinx.*—Body large, bell-shaped; lateral foot scarcely visible; teeth curved and bifid at the points. This species is very similar to the former, and only distinguished from it by its small foot and the

spaces within the cilia cluster (mouth) being convex, not concave. Found in a turf pool. Length 1-40th.

NOTOMMATA *hyptopus.*—Body bell-shaped, nearly globular, rather large; foot slightly prominent at the middle, teeth small; vibratile organ composed of four or five muscular bundles; œsophagus very short. Length 1-72nd.

N. *parasita.*—Body small, oval; foot short, teeth small; rotatory apparatus, three or four lobes; œsophageal head globose; œsophagus short; alimentary canal stout, simple, usually filled with green matter. This curious animalcule lives in the globes of *Volvox globator,* where it deposits its eggs, which are therein hatched; and when of proper age, the creatures eat their way out through the hollow sphere. Length 1-40th.

N. *granularis.*—Body short, cylindrical, truncated at both ends; foot slender. The body has always a few dark granular bodies within it. Dr. E. discovered it in 1831. In 1835 he observed eggs of two sizes on the dorsal surface of N. *brachionus;* the smaller ones were distinguished by dark granules within them, and produced N. *granularis.* From other observations, he concludes these eggs of N. *granularis* are deposited by the parent upon N. *brachionus,* like the cuckoo, who lays her eggs in the nests of other birds. Length 1-280th.

N. *petromyzon.*—Body elongated, attenuated at both ends; mouth and rotatory organ lateral. Ehrenberg says, in May, 1835, he found one in a *Volvox globator,* whose gemmiferous masses it eats likes N. *parasitica.* The eggs are often deposited on *Epistylis.* Length 1-180th to 1-144th.

N. *lacinulata* (*Vorticella auriculata, et arcinulata,* M.)—Body small, conical, truncated, and slightly lobed in front; teeth extended, often bicuspid. This species is very active. Found with *Chlamidomonas pulvisculus* in clear water; also in water tubs. Length 1-280th.

N. *forcipata.*—Body small, elongated; toes long, and often crossed; eye very large. The vibratile organ appears sometimes like a simple wreath. Found amongst Lemna. Length 1-180th.

N. *collaris.*—Body elongated, large, gradually attenuated at both ends; neck turgid; toes short. It swims slowly, the vibratile organ being small in comparison with the body. Length 1-48th.

N. *Werneckii.*—Body elongated, gradually attenuated at both ends

toes short. It has two setæ near the mouth. This animalcule resembles N. *collaris,* but is smaller, and lives in the club-like excrescences of Vaucheria as an entophyte. Length 1-90th.

NOTOMMATA *najas.*—Body conical, cylindrical, stout, truncated in front; no auricles. It resembles *Hydatina senta* and *Eosphora najas ;* it is distinguished from the first by its cervical eye, from the latter by want of frontal eyes. Amongst Lemna. Length 1-120th.

N. *aurita* (*Vorticella aurita,* M.)—Back swollen near the tail, and thus gibbous; the corners at the front project like ears. Beneath the eye is an obscure white, globular, purse-shaped organ. Found amongst Conferva, &c.; also beneath ice. Length 1-200th. (P. 23, f. 3, 4, 5, 6.)

N. *gibba.*—Back swollen, front truncated, not auricled, no cerebral sacculi below the eye; toes short; the vibratile organs compound. Found in old exposed infusions. Length 1-200th.

N. *ansata* (*Vorticella aurita,* M.)— Body turgid in the middle, suddenly truncated at both ends; the front auricled, no cerebral sacculi below the eye; toes thick. Found in bog-water amongst Conferva. Length 1-120th.

N. *decipiens.* — Body cylindrical, not auricled; toes short; the ovarium often contains four large eggs. Length 1-180th.

N. (?) *felis.*—Body small, slender; one horn in front; eye colourless; back attenuated posteriorly, and forked. Length 1-240th.

N. (?) *tigris* (*Trichoda tigris,* M.)—Body cylindrical, curved, foot half the length of body; toes very long, and curved downwards; it has a little horn in front; the eye is large and red. Found amongst Oscillatoria. Length 1-72nd.

N. *longiseta* (*Vorticella longiseta,* M.)—Body cylindrical, truncated anteriorly; toes styliform, unequal, and two to four times longer than the body; it is active, and frequently leaps, being assisted by its long claws, which resemble tails. Fig. 421 is a full-grown specimen. Entire length 1-60th.

N. *æqualis* (*Vorticella longiseta,* M.)—Body cylindrical, obtuse in front; toes styliform, equal the length of the body. Length 1-120th.

(*b.*) *Sub-genus* CLENODON.—*Jaws many-toothed.*

N. *clavulata.* — Body bell-shaped, foot conical, very short; pancreatic glands of a club-shape. This creature presents great facility

for observing its internal structure, but the limits to which I am restricted preclude my entering into its interesting details. Length 1-96th.

NOTOMMATA *tuba*.—Body conical, trumpet-shaped, dilated anteriorly; foot furcated and acute. It resembles, in form, *Stentor Mülleri*, but is more active. Length 1-120th.

N. *brachionus*.—Body dilated, nearly square, depressed, foot slender, eggs pendulous. This creature appears to have a shell, but Dr. E. says it has not: N. *granularis*, as before remarked, lays its eggs upon it. Length 1-96th.

N. *tripus*.—Body oval, sub-truncated, and slightly auricled in front; it has a short, styliform, true tail, and forked foot. Length 1-200th.

N. *saccigera*.—Body elongated, cylindrical, attenuated posteriorly; fork short. It has a curious internal pouch beneath the eye; vibratile organ lateral, as in *Pleurotrocha*. Length 1-144th.

N. *copeus*.—Body large, attenuated at both ends; tail small, and indurated. This curious creature has a long bristle on each side of its body; and on each side of the head a stout branch, called, by Dr. Ehrenberg, an auricle, having vibratile cilia around the ends, and, like the setæ, standing out, so as to appear like a cross; a thick gelatinous substance covers the body; the back terminates in a somewhat hard point, which is a true tail, between which and the foot the discharging opening is situated. When creeping, the large vibratile arms are withdrawn, but it vibrates with the frontal cilia and proboscis. Fig. 416 represents the creature extended. Length 1-36th.

N. *centrura*. Body large, attenuated at both ends; tail small, indurated; auricles small, and no lateral setæ present. It is often enveloped in a thick slime, in which articulated threads of Hygrococis vegetate, giving the animal a hairy appearance. It swims awkwardly. Length 1-36th.

N. *brachyota*.—Body small, slightly attenuated towards the ends; no tail, auricles very small; it has two dark spots near the eye; foot forked. Length 1-120th.

N. *Pleurotrocha*.—Body slender, cylindrical, not auricled; foot with very short toes; eye obscure, ovate, large; jaw with one tooth. Length 1-144th. Berlin. Has the form of *Pleurotrocha*.

NOTOMMATA *vermicularis* (Duj.)—Body vermiform, very contractile; of variable form, with a kidney-shaped red speck, in which is partly imbedded a white transparent globule. Length 1-118th. Found in the Seine.

Genus SYNCHAETA. *The bristle-headed Rotatoria* have a single cervical eye; compound rotatory organs, of six to ten lobes, and armed with from two to four styles; foot furcate. The strong styles, or bristles, are situated between the clusters of cilia, and, probably, act as organs of prehension; the body is very short, and broad anteriorly, tapering to a point posteriorly, so as to resemble a cone. Internal longitudinal muscles exist in all the species; those of the foot are seen in three species: the œsophageal head is large, with single-toothed jaws, and exists in all the species; but in two only is the whole chewing apparatus distinctly seen. The thin œsophageal tube is long in two species, short in the rest; it leads to a simple, wide, conical, alimentary canal, which has two roundish, or, in one species, conical pancreatic glands. The ovarium is rolled up like a ball; contractile vesicles exist in three, and glands in two species; transverse bands (four to ten) are visible in two species; and a respiratory tube, probably, in S. *pectinata* and S. *tremula*, a tremulous gill being also present in the former. The principal nervous matter is a knotty mass surrounding the head of the œsophagus, and in the middle of it is a large, roundish, red eye. In S. *pectinata* three pair of ganglia and strong nerves are also seen. (For remarks on the genus, see *Hydatina*, p. 628.)

S. *pectinata*.—Body short, conical, with two styles, and two crest-like horns anteriorly. "Are these horns," asks Ehrenberg, "respiratory tubes, as in *Polyarthra*, and in *Anuraea*?" The liveliness and uniform transparency of this animalcule render it difficult to distinguish its various organs. The styles arise from the muscle of the œsophageal head, and appear as if belonging to simple-toothed jaws. Fig. 422 represents a view of this creature (dorsal side), and of its organization. Found amongst Conferva. Length 1-120th.

S. *Baltica*.—Body ovate; rotatory clusters and styles, four each; crest single, sessile. This creature is supposed to occasion phosphorescent light in the ocean. In two samples of water received by

Dr. Ehrenberg at Berlin, from Kiel, the luminous property existed, but this species, though present, did not evolve any light. Dr. Michaelis, however, has noticed the production of light from this *Synchaeta*, and Dr. Ehrenberg thinks it only takes place when developing ova. Length 1-100th.

SYNCHAETA *oblonga*.—Body oblong, with six rotatory clusters, and four styles; crest sessile and single. Distinguished from the following by the form of the pancreatic glands. Found amongst Conferva, in spring. Length about 1-100th.

S. *tremula* (*Vorticella tremula*, M.)—Body truly conical, with six rotatory clusters, four styles; crest none. Length about 1-160th.

S. *mordax* (Gosse.).—Body conical, subventricose; toes minute; auricles large, pendent; principal styles four; the larger (or lateral) pair sometimes branched; eye rather small, brilliant; two pairs of protrusile snapping jaws. Length 1-72nd.

Genus SCARIDIUM. *The Springer.* — Eye cervical, single, flat, lenticular, the compound rotatory organ armed in front with an uncinus, or hooked bristle; foot forked, very long, and adapted for leaping or springing—hence the name. An oblique œsophageal head, with unequal, double-pointed (single) teeth to the jaws; a short, narrow œsophagus, opening into a simple, wide, conical, alimentary canal, with two spherical pancreatic glands, constitute the nutritive system. Posteriorly, about the intestine, are a ball-like ovarium and a contractile vesicle; the foot has two club-shaped muscles; a central ganglion exists between the rotatory lobes; the apparent articulations of the foot are very remarkable.

S. *longicaudum* (*Trichoda longicauda*, M.)—Foot twice as long as the body, toes half as long as the foot; the animal springs or leaps quickly, by a rapid movement of the foot; it does not appear to have a lorica, and is remarkable from all other Rotatoria by the length and bending in of the foot, which, as also the body, is covered with a stiff skin. Behind the eye is a transverse fold in the neck, where the head draws itself into the body; the foot has also a transverse fold when it bends. Fig. 423 represents the animalcule extended (right side); fig. 424 the œsophageal head, with unequal jaws, &c., extended by pressure. Found amongst Oscillatoria. Entire length of the body 1-72nd; without the foot, 1-216th.

Genus Polyarthra. *The many-finned Rotatoria* have a single cervical eye, no foot, but are provided with cirrhi, or pectoral fins; the rotatory organ consists of four bundles of cilia, inserted in as many muscular sheaths; they sometimes appear like the double rotatory organ of a *Brachionus,* and the form of the body resembles *Anuræ;* but it is, however, soft, and the rotatory organ double; laterally, two longitudinal dorsal muscles are known; the frontal region has little horns, provided with bristles, and upon the breast six strong styles, or barbs, forming two clusters, which move in a fin-like manner. The system of nutrition consists of an œsophageal head, having two single-toothed jaws, a short œsophagus, an alimentary canal, with a stomach-like division, produced by a constriction, and two pancreatic glands. An ovarium exists in both species, and in one of them a contractile vesicle; nothing is known of the vascular system, unless the two soft horns at the brow are respiratory tubes; a large frontal ganglion, and a round red eye, indicate the system of sensation.

The preceding genera of this family *Hydatinæa,* form, together with two peculiar to himself, viz., *Plagiognatha* and *Lindia,* in the system of Dujardin, the family *Flosculariens;* but this genus *Polyarthra,* and a few others in this family of Ehrenberg, belong to the *Brachioniens* of the above-named author.

From the remarks of the French naturalist, it is to be inferred that he regards the distinction between *Polyarthra* and *Triarthra,* as insufficient to characterize them generically.

P. *trigla.*—Body oval, almost square, having six setaceous pinnæ. It swims quickly, and often leaps, like the water-flea; this last motion is produced by the fins, or pinnæ, the former by the vibratile organs. Fig. 425 represents the under side, while the animalcule is swimming, with the pinnæ depressed; fig. 400 a dorsal view, while leaping, or springing; and fig. 401 a side view (right.) This creature is infested with *Colacium.* Found amongst Conferva. (1-140th.)

P. *platyptera.*—Body oval, almost square, with six serrated broad sword-shaped pinnæ. It is represented at fig. 402. Found amongst *Chlamidomonas.* Length 1-190th.

Genus Diglena (?). *The two-eyed Rotatoria.*—Eyes two, frontal; foot forked. Excepting the foot, and rotatory organ, they have no

external prominent organ, though some protrude the teeth in a pincer-like manner. The nutritive apparatus is a muscular œsophageal head, having single-toothed jaws; an œsophageal tube, very short, except in D. *lacustris;* a simple conical alimentary canal in six species; and a constricted one, or stomach, in two species. In all, two pancreatic glands are present, which, in D. *lacustris,* are long, cylindrical, and two-horned; in the rest they are spherical. The ovarium, in D. *lacustris,* is band-like; in the others, like a ball; contractile vesicles are observed in four species; sexual glands in three. No species is viviparous; none carry their egg hanging to them; transverse vessels are seen in three species, and in one a vascular net-work at the head; tremulous gills are found in three species, in two of which they are evidently attached to the sexual glands. The nervous system is more especially developed in D. *lacustris,* but indicated in all the species by the coloured eyes. (For observations on this genus, vide ante, p. 626.)

Diglena *lacustris.*—Body stout, oval, crystalline; the front straightly truncated; foot suddenly attenuated, in length one-fourth of the body; the toes one-third the length of the foot. The transparency of this animalcule is often a great hindrance to the discrimination of its internal organs, though they are very large; the superficial skin is delicately shagreened. Fig. 403 represents a side view (left) of this interesting animalcule, with a Lynceus (see *Microscopic Cabinet,* plate vii.) in its stomach; its curious internal organization is clearly depicted. Often found in green-coloured water. (1-70th.)

D. *grandis.*—Body long, slender, and cylindrical, obliquely truncated anteriorly; toes straight, longer than the stout foot. The forked central cacculus, between the two ocular ganglia, is remarkable. Fig. 404 is a side view (right) of an extended animalcule; fig. 405 another, contracted, with the jaws pushed out. Length 1-120th to 1-72nd.

D. *forcipata* (*Vorticella vermicularis, Cercaria forcipata et E. vermicularis* M.)—Body cylindrical, slender, obliquely truncated anteriorly; toes decurved, and longer than the stout foot. Length 1-110th.

D. (?) *aurita* (*Vorticella canicula,* M.)—Body cylindrical, slender; front straightly truncated, auricled; foot suddenly constricted, toes small. The tremulous organ (heart) observed by Corti was merely

the vibratile lining membrane of the anterior portion of the alimentary canal. Found amongst Conferva. Length 1-160th.

DIGLENA *catellina* (*Cercaria catellina, Vorticella larva,* M.)—Body oblong, short, ends truncated; foot short, and inferior. The small size of this animalcule is unfavourable for observing its internal organization. It is found at all seasons of the year in open water, and in infusions covered with a green pellicle, which is often filled with its eggs; these, when rapidly developed by genial weather, cause a milky turbidity in the water. Length 1-360th.

D. *conura.*—Body ovato-oblong, straightly truncated in front, and gradually attenuated to a conical foot. Found amongst Oscillatoria. Length 1-144th.

D. *capitata.*—Body oblong, conical, obliquely truncated, and dilated in front; toes long, without apparent base, or foot. This animalcule feeds upon *Chlamidomonas* and *Naviculæ.* Length 1-300th.

D. *caudata* (*Vorticella furcata,* M.) — Body elongated, conical, obliquely truncated anteriorly, but not dilated; foot distinct, short; toes long. Found in green water. Length 1-200th.

D. (?) *biraphis* (Gosse.)—Body oblong, the head and abdomen gently swelling; toes long, slender, straight, and perfectly even in thickness; eyes placed close together, frontally; jaws protrusile; alimentary canal very large, projecting behind and above the gizzard, always filled with green matter. Length including toes 1-110th.

Genus TRIARTHRA. *The three-bearded Rotatoria* possess two frontal eyes, a simple styliform foot, and beard, or breast fins. Beside the rotary organ, internal band-like muscles are observed, and two bristles, or fins, which assist in leaping, as in *Polyarthra.* The nutritive apparatus consists of an œsophageal head, having four muscles, and two double-toothed jaws, as in *Rotifer;* an œsophageal tube, long in one species, short in the other; and a simple, conical, or constricted alimentary canal, with two spherical glands. Both ovarium and contractile vesicles are seen; the eggs, when expelled, remain attached by threads. A vascular system is unknown,—the nervous is indicated by the two red eyes, placed upon ganglia. Both species often produce a milky turbid appearance in the water, when developed in masses.

T. *longiseta* (*Trichoda,* M.)—Eyes distant, the cirrhi or beards,

and the foot, are nearly three times the length of the body. This species is distinguished from the following one by the greater length of cirrhi; by larger eyes, further removed from each other; by a distinct stomach, with a constriction separating it from the long portion of the alimentary canal; and, lastly, by its long œsophageal tube. It is readily distinguished by its leaping movement whilst swimming. Fig 408 represents one of these creatures emerging from the egg, the cirrhi or styles being, as yet, soft: fig 407 is a back view of a young specimen; it shews the great separation of the eyes and the styles, in the position they occupy when the animal is swimming; and fig. 406 is a side (right) view of a full-grown specimen; the styles are advanced, preparatory to leaping. Found with *Hydatina senta* and *Brachionus urceolaris*. Length, without cirrhi, 1-140th.

Triarthra *mystacina* (*Brachionus passus*, M.)—Eyes close together; two anterior cirrhi, or bristles; foot nearly double the length of the body; jaws very soft. Found in water-tubs. Length 1-216th.

T. *breviseta* (Gosse.) — Body cylindrical; pectoral and caudal spines each about one fifth of total length, and very slender. Length, including foot, 1-185th. Leamington.

Genus Rattulus. *The rat Rotatoria.*—Frontal eyes, two; foot simple, styliform; no cirrhi or beard. Several undefined rotary muscles, an œsophageal head, without distinct teeth or œsophageal tube, a simple conical alimentary canal, with two round glands, an ovarium, and eyes, constitute the organization at present discovered.

This genus *Rattulus* or *Ratulus* was established by Lamarck; but was subdivided by Ehrenberg who made two genera, *Mastigocerca* and *Monocerca*, to comprise the animals described by Lamarck, and reserved the term *Rattulus* for an animal placed by the latter among Cercaria, and called by Müller, *Trichoda lunaris*. The *Mastigocerca carinata* (Ehr.) is described as loricated, and enters into the family *Euchlanidota*, and *Monocerca rattus* without lorica, is placed among the *Hydatinæa*; but the beings described under these two appellations represent but a single species, *Ratulus* . . . . The *Monocerca bicornis* of Ehrenberg would seem to be a distinct species, by reason of the horns with which it is armed in front.

RATTULUS *lunaris* (*Trichoda lunaris*, M.) Body small; eyes remote from the frontal margin; foot decurved, lunate. No teeth are seen. Group 409 represents two of these animalcules. Found in turfy pools. Length 1-288th.

Genus DISTEMMA. *The double-star Rotatoria* have two cervical eyes and a forked foot; the rotary organ is compound. The nutritive apparatus consists of an œsophageal head, which in three species has jaws, with two teeth each; in one species with more than two, a short œsophageal tube, and a simple conical alimentary canal, with two spherical glands. An ovarium, and in D. (?) *marinum* glands and a contractile vesicle are seen. No satisfactory details of a vascular system are ascertained, but that of sensation is illustrated by the presence of eyes, which are red, except in one species, in which they are colourless. In all the species, except D. *marinum,* the eyes are situated behind the head of the œsophagus, but in that one they are anterior, but below the rotary organ. The eggs are never attached to the parent, nor are they developed in large masses.

D. *forficula.*—Body cylindrico-conical; eyes red; toes thick, recurved and dentate at the base. The eyes are placed at the end of a long cylindrical nervous ganglion; the rotary organ consists of four parts. Fig. 411 is a side (left) view, and fig, 410 shews the jaws extended for seizing prey. Length 1-120th.

D. *setigerum.*—Body ovato-oblong; eyes red; toes setaceous and decurved. Length 1-216th.

D. (?) *marinum.*—Body ovato-conical; eyes red, close together; foot long; toes thick, the length of the foot; jaws many-toothed. Found in sea-water. Length 1-144th.

D. (?) *forcipatum.*—Body ovato-oblong; eyes colourless; foot short, with stout toes. If the two colourless vesicles are not eyes it must be placed in the genus *Pleurotrocha.* Length 1-288th.

Genus TRIOPHTHALMUS. *The row-eyed Rotatory Animalcules.*—Eyes three, cervical, sessile, in a row; foot forked; rotatory organ compound. It has a large œsophageal head, with two (single-toothed?) jaws, a long thin œsophagus, a globose stomach-like protuberance, with two oval glands, and thin posterior alimentary canal; two muscles move the foot.

TRIOPHTHALMUS *dorsalis*.—Body crystalline, turgid; foot suddenly attenuated, its length half that of the body. This species, in form, resembles *Notommata ansata*, but in size N. *myrmeleo*. Fig 412 represents (dorsal side) an animalcule extended as it appears when swimming and vibrating; fig 413, one in the act of unfolding itself; and fig. 414, another contracted. Length 1-40th.

Genus EOSPHORA. *The three-eyed Rotatoria.*—Eyes three, sessile, two frontal, one cervical, foot forked. The rotatory organ is composed of numerous muscular portions, and distinctly striated longitudinal muscles are seen in all. An œsophageal head, provided with two single toothed jaws, a short œsophagus, a simple conical alimentary canal, with two ovate glands anteriorly, an ovarium, somewhat extended, sexual glands, and a contractile vesicle, are also discoverable. Transverse vessels are observable in two species, and in the third, gills. No respiratory tube has been discovered. Beside the three red coloured eyes, a cerebral ganglion is seen.

E. *najas*.—Body conical, transparent, not auricled; toes much shorter than the foot. Fig. 415 represents an animalcule fed upon indigo. Found amongst Conferva. Length 1-12th

E. *digitata*.—Body conical, hyaline, not auricled; toes a third the length of the foot. Found amongst Conferva. Length 1-96th.

E. *elongata*.—Body elongated, almost fusiform, not auricled, front truncated; toes short. Length 1-72nd.

Genus OTOGLENA. *The pedicle-eyed Rotatory Animalcules.*—Eyes three, one being sessile and cervical, the others pedicled and frontal; foot furcated. This large animalcule has considerable resemblance to *Notommata myrmeleo*, or N. *clavulata*. Four lateral longitudinal muscles, six moving the rotary organ, and two muscles of the foot, are present; a toothless, and apparently jawless, œsophageal canal, leads to a somewhat thickened stomach, ending in a very thin alimentary canal. Ovarium, contractile vesicles, and two sexual glands, exist. In the middle of the back appears to be a respiratory opening; this, with a vascular net-work at the neck, and four transverse circular canals, represent a vascular system. An oval cerebral ganglion, with two dark appendages, a red eye, a long nervous loop on the neck, that runs back to a second ganglion in the brow,

and a forked ventral nerve (?), together with two little horn-like or auricular frontal protuberances, bearing two visual points, represent the sensitive system. This genus has not been figured.

Otoglena *papillosa*.—Body bell-shaped, turgid, scabrous with papillæ. Found with *Volvox globator* and *Notommata myrmeleo*. Length 1-96th.

Genus Cyclogena. *The ring-eyed Rotatoria.*—Eyes numerous, (more than three), simply conglomerate at the neck, foot furcate. The vibratile organ is compound; and with the internal muscles of the foot, serve for locomotion. There is an œsophageal head, with two single-toothed (perhaps three-toothed) jaws, a very short œsophagus, and a simple conical alimentary canal, with two roundish glands. An ovarium, two sexual glands, and a contractile vesicle are also present. Transverse circular vessels, and six pair of tremulous organs attached to the seminal glands, constitute the vascular system. A purse-shaped dark (colourless) body in the neck, connected by a narrow process to a large frontal ganglion, containing from six to twelve red points, of which the anterior one is most marked, indicate a sensitive system.

C. *lupus* (*Cercaria lupus*. M.)—Body ovato-oblong, or conical, not auricled; foot terminal, and short. Plate 10, fig. 425,* represents a back view, and fig. 426 a side view. Length 1-120th.

C. (?) *elegans*.—Body ovate, not auricled; foot inferior; toes long. Length 1-190th.

Genus Theorus. *The many-eyed Hydatinaea.*—Eyes numerous, (more than three), disposed in two groups at the neck; foot furcate. A compound rotary organ, together with two muscles of the foot, an œsophageal head, with two one-toothed jaws, a short œsophagus, a simple conical alimentary canal, with two glands, a ball-like ovarium, with two male sexual glands, and a double group of colourless cervical eyes, are the details of the organization at present known. The frontal uncinus, or hook, is perhaps a respiratory tube.

T. *vernalis*.—Toes small; no frontal uncinus. The movement of this creature is active and vehement, like that of an animal of prey. Fig. 427 represents a back view of this animalcule extended, with six colourless eyes in each group; fig. 428 is another specimen

with four eyes; and fig. 429 an animalcule with body contracted, but jaws extended. Found amongst Oscillatoria. Length 1-140th.

THEORUS *uncinatus.*—Toes long, a frontal uncinus or hook present. Six visual points have been seen by Ehrenberg. Found amongst Oscillatoria. Length 1-240th.

The two next genera mentioned are from Mr. Gosse, who, however, adduces the latter as a doubtful member of the present family.

Genus ASPLANCHNA (Gosse.) (Annals Nat. Hist., vol. 6, July, 1850.)—Rotatorial hydatinæa destitute of foot, intestine, and anus; but possessing eyes (ocelli) and jaws; sexes disjoined.

This new genus, instituted by Mr. Gosse, embraces the Rotatorial animal which Mr. Brightwell introduced to notice as "a supposed new species of *Notommata*:"—(Fauna Infusoria, Norfolk 1849), and in which he first detected the existence of male animals, distinct in organization and character from the female. It was soon perceived that the new forms represented by Mr. Brightwell, could not belong to the genus *Notommata* of Ehrenberg; and the discovery of other similar beings has led to the creation of this genus *Asplanchna.*

A. *Brightwellii.* — Jaws (mandibles) one-toothed; eye single; stomach oval, longitudinal; vesicle lobed, larger; tremulous corpuscles (gills, Ehr.) affixed to a long filament; ovary two-horned. Length about 1-24th. (P. 15, f. 65, 66.) Males with jaws, pharynx and stomach absent; body truncate. Length about 1-40th. Found at Norwich, Leamington, Hampstead Heath, &c."

Mr. Brightwell's account is embraced in the following extracts:—

"It (the female) is furnished with an ovisac, in which the young may be clearly detected, and from which they are expelled through the sides of the animal. Some of the young appear to differ in form from the others, and there appear to be two kinds of ova; one, and that by far the greater number, transparent, and hatched in the body of the parent; the other, more opaque, perhaps remaining unhatched, or deposited till vivified under favourable circumstances, in some ensuing season. Should this, on further

investigation, turn out to be the case, we shall have, among the *Rotifera*, the same mode of preserving the ova during the winter, as is found in some of the *Entomostraca*, the *Daphniæ* for instance."

"These (the males) are smaller than the females, and have a pyriform sac below, from which there is an opening, and which is filled with spermatozoa; and they have neither jaws, nor gullet, nor stomach; and it would seem they are designed, as is the case with the males of some insects, to continue the race and then to perish. . . . I have lately repeatedly seen the male in connection with the female. He attaches himself to her side by his sperm-tube, and remains attached from twenty to seventy seconds."

For a more complete description of these very interesting forms' we may refer the reader to the elaborate details and figures of their organization, by Mr. Dalrymple, in the "Philosophical Transactions" for 1849.

ASPLANCHNA *Priodonta* (Gosse.) *Females.*—Jaws serrated; eyes three; stomach hemispherical, transverse; vesicle spherical, smaller; tremulous, bodies attached to a twisted and plicate filament; ovary subglobose, (P. 23, f. 9.) Length about 1-48th. *Males.*—Body acute. (P. 23, f 7, 8.) Length 1-110th. Found in the Serpentine River. (P. 23, and f. 11, 12, exhibit the jaws of the female detached.)

Genus TAPHROCAMPA (Gosse.)—Rotary organs wanting, body fusiform, annulose; tail forked; gizzard oval; mallei incurved, shorter than *incus*, which is also incurved.

T. *annulosa.*—Occipital mass opaque, white; alimentary canal simple, wide, cylindrical; points of tail short, conical. Length 1-110th. This species is evidently allied to M. Dujardin's *Lindia torulosa*, but differs from it in the structure of the dental apparatus, and of the digestive canal. It seems to connect the genus *Choetonotus* with the Hydatinœous genera *Notommata* and *Furcularia*, for it has the jaws of these larviform *Rotifera*, and the glandular occipital mass found in some of them, with the form, simple digestive canal and manners of *Choetonotus*. Found at Leamington.

We will append here two genera of the family *Furculariens*, of Dujardin, which that naturalist has created either to embrace new

species, or to dispose of those described by Ehrenberg, which Dujardin cannot include with other of his genera. Likewise, before commencing with the next family *Euchlanidota*, of Ehrenberg, we shall take the opportunity to detail the characters of a family discovered and named by Dujardin, viz. *Albertiens.*

Genus *Plagiognatha.*—Body oblong, curved and convex on one side, or cornet shaped and obliquely truncate in front; terminated posteriorly by a more or less distinct tail, bearing two styles. Jaws with parellel branches turned the same way, and recurved towards the ciliated margin with a straight central stem *(fulcrum)*, very long and enlarged at its base; eye specks one or two. We propose this as a genus of *Furculariens.*

Although possessing a curved figure, with a characteristic form of jaws, Ehrenberg has distributed them in his genera *Notommata, Diglena,* and *Distemma,* according to the number and disposition of their red points, and without consideration of the characters we employ.

The species we regard as the type of this genus is, the P. *Felis,* called by Müller, *Vorticella felis,* but not answerable to the *Notommata felis* of Ehrenberg. Its two styles are one fourth of its entire length, and are curved backwards; the back is convex, abruptly truncate behind. Length 1-118th.

A second species, P. *lancinulata,* has been classed by Ehrenberg among the *Notommata.* A variety of this species with two eye specks may be referred to the *Distemma setigerum.* (Ehr.)

One must also regard as distinct species of *Plagiognatha* the *Notommata tigris,* and the *Diglena catellina* of Ehrenberg. The *Diglena lacustris* of the same author also corresponds in form; but its jaws are not sufficiently described to determine its position; whilst his *Notommata hyptopus,* represented with one-toothed jaws, analagous to those of our *Furcularia,* appears the same as a *Systolide* known to us, evidently possessing the jaws of a *Plagiognatha.*

Genus Lindia.—Body oblong, almost vermiform, with transverse folds, rounded in front, but not ciliated, terminated posteriorly by two short conical toes. Jaws very complicated, with a triple branch. I propose this as a genus of *Systolides.*

L. *tortulosa,* having the general form of *Notommata vermicularis,*

from which it is distinguished by the absence of vibratile cilia, and of a red eye speck, and especially by the singular structure of its jaws. Length 1-76th. Found near Paris.

Family.—ALBERTIENS.

Body cylindrical, vermiform, round in front, with an oblique opening, from which a ciliated organ protrudes itself, almost larger than the body; terminated posteriorly by a short conical tail. Jaws in the form of hooks, simple, or with one tooth each.

This family comprises but one genus, and one species, *Albertia vermicularis*, which is found parasitic in the intestine of *Lumbrici* and snails. Length 1-79th to 1-47th.

The ova with their embryos are seen in its interior, in various stages of development.

The ciliated apparatus, in advance of the mouth, is surrounded by an appendage in the shape of a spur (calcar.)

Family.—EUCHLANIDOTA.

Comprehends loricated Rotatoria whose rotary organ is compound, being divided into several parts, always more than two. The shell-like covering, says Dr. E., resembles either that of tortoises or that of crabs; the former when only open at the ends (*testa testula*), the latter when open also on the under side, or back, forming a little shield *(scutellum.)* As appendages, we find setæ in *Euchlanis* and *Stephanops;* uncini in *Colurus*; little horns in *Dinocharis;* spurs, or respiratory tubes, in *Euchlanis* and *Salpina;* and a hood in *Stephanops*. They also possess a foot, mostly furcate, but in a very few simple and styliform. Only three species are destitute of eyes. Separate muscles for moving the rotary organs exist in all the genera, and internal free ones in three species of the genus *Euchlanis;* muscles for moving the foot are also visible. The nutritive apparatus consists of a muscular œsophageal head, with two jaws provided with teeth; these are free *(gymnogomphia)* in all the species examined. They have a very short œsophagus. Eight genera have

either a simple conical stomach *(coelogastrica),* or else one produced by a constriction of the alimentary canal *(gasterodela.)* Two round or ovate intestinal glands are also seen. The discharging opening is at the base of the foot, upon the dorsal surface, which latter is clearly indicated by the situation of the eyes, when present. The ovarium developes but few large ova at a time; two sexual glands and a contractile vesicle exist in the genera *Euchlanis, Monostyla, Stephanops,* and *Squamella*—the latter only in *Metopidia, Lepadella,* and *Mastigocerca.* They do not carry their ova externally. Traces of a vascular system are seen in two species of *Euchlanis,* and perhaps also gills in *Dinocharis,* whilst the respiratory tube in *Salpina* and *Euchlanis* must be considered as such. The nervous system is indicated in ten genera by the presence of red visual points, whose situation and number are useful in establishing generic characters; an evident cerebral ganglion (as a nervous layer to the eyes) is found in *Euchlanis, Monostyla, Mastigocerca,* and *Salpina.* The genus *Lepadella* developes itself occasionally in such myriads, in stagnant water, as to give a whitish turbidity to it.

The genera are disposed as follow :—

No eyes, foot furcated					Lepadella.
Eyes present.	one eye (cervical.)	foot styliform	lorica depressed		Monostyla.
			lorica prismatic		Mastigocerca
		foot furcate	lorica gaping beneath		Euchlanis.
			lorica closed beneath	lorica horned	Salpina.
				without horns	Dinocharis.
	two eyes (frontal.)	foot styliform			Monura.
		foot furcated	lorica compressed laterally or cylindrical.		Colurus.
			lorica depressed or prismatic	head not hooded	Metopidia.
				head hooded	Stephanops.
	four eyes, foot furcate				Squamella.

These genera are mostly included in the family *Brachioniens* of Dujardin.

Genus Lepadella. *The scaled Rotatoria* are devoid of eyes, but possess a furcate foot. Several rotatory muscles are seen, and foot ones in two species. The jaws of the œsophageal head are single-toothed in L. *ovalis* and L. *emarginata;* in L. *salpina,* triple-toothed. The tube of the œsophagus is very short in all. The alimentary canal is constricted, except in L. *salpina,* in which it is simple. The ovarium is globular in all, and a male sexual vesicle is present in L. *salpina,* in which species, probably, a cerebral ganglion (no eye) also exists. L. *ovalis* is sometimes developed in myriads in stagnant water.

Dujardin has the following criticisms on the genus *Lepadella,* "Wishing to derive his generic characters too exclusively from the eye specks, Ehrenberg has separated all those having such specks into several genera; constituting of those with two eye points, the genera *Stephanops,* and *Metopidia,* and of those with four red specks, the genus *Squamella.* But we are convinced that these red points may be present or absent in the same species at different periods of development. We believe, for instance, that the *Lepadella ovalis* and *Stephanops muticus,* Ehr., are but a single species. *Lepadella patella* with or without red dots; so also the *Metopidia lepadella* and *Squamella bractea* are the same, and what we name *Lepadella rotundata.* Moreover, the *Squamella oblonga,* and *Metopidia acuminata,* are two distinct species of *Lepadella.*"

L. *ovalis* (*Brachionus ovalis,* M.) — Lorica depressed, oval, attenuated anteriorly, the ends truncated; it is not emarginate. The alimentary canal of this animalcule is generally filled with a yellowish substance, except when it feeds upon colourless Monads. Fig. 430 represents a back view; fig. 431 a side (right) view of a young specimen; fig. 432 the lorica; fig. 433 the œsophageal head (1-240th.)

L. *emarginata* (*Brachionus spatella et ovalis,* M.)—Lorica depressed, oval, broad anteriorly, extremities emarginate. Found amongst Conferva. Length, without foot, 1-576th.

L. (?) *salpina.*—Lorica oblong, prismatic, obtusely triangular, back crested, denticulated. Found amongst Conferva. Length of lorica 1-200th.

Genus Diplax (Gosse.)—Resembles *Salpina,* but the eye is wanting, and the lorica (which, as in that genus, is cleft down the back) is

destitute of spines both in front and rear; foot and toes long and slender. It forms a connecting link between *Salpina* and *Dinocharis.* The name signifying double, alludes to the gaping lorica, which forms two parallel plates.

In accordance with the tabular disposition of the family, this genus follows next after *Lepadella.*

Diplax *compressa.* — Form of lorica (viewed laterally) nearly a parallelogram, greatly compressed. Lorica 1-176th.

D. *trigona.*—Lorica three sided, a section forming a nearly equilateral triangle, surface delicately punctured or stippled; toes long and slender. Lorica 1-160th. Leamington.

Genus Monostyla. *The spinous-footed Rotatoria.*—Eye single, cervical; foot simple, styliform; lorica (*testula*) depressed. Numerous rotatory muscles are seen in two species, and also an œsophageal head, having four muscles; in one species the jaws are single-toothed, in the other two-toothed. They have a very short œsophagus, and a constricted stomach (*gasterodela*), with two glands. The ovarium is globular; an ovum, with the vesicle of the germ within it, is seen in two species. No male organs, vessels, nor respiratory tubes, are seen. Owing to the almost constant vibration of the foot-like tail, it is difficult to observe the true form of its termination, the motion producing an optical deception: hence it appears double, though in reality it is single.

M. *cornuta* (*Trichoda cornuta,* M.)—Lorica hyaline, unarmed, and truncated anteriorly. Found amongst Chara and Conferva. Length 1-250th.

M. *quadridentata.* — Lorica yellowish, anteriorly deeply dentated, resembling four horns. It is generally of a yellow leather colour, but Ehrenberg has seen it colourless. Figs. 434 and 435 represent ventral views of this animalcule; in the latter it is extended beyond its lorica, which happens when the rotatory cilia are in motion. Fig. 436 shews a side view, and fig. 437 the jaws and teeth separate. Found in floccose matter about Conferva and the leaves of water-plants. Length 1-120th.

M. (?) *lunaris.*—Lorica hyaline, anteriorly crescent-shaped. Length 1-144th.

M. *bulla* (Gosse.)—Body ovate, inflated, the back very gibbous;

lorica plicated on each side with a deep furrow; the occipital and mental deeply incised. Colour yellowish-brown. Length of lorica 1-175th.

Genus Mastigocerca. *The whip-tailed Rotatory Animalcule.*—Eye single, cervical; foot simple, styliform; lorica prismatic and crested on the back. It has a four-partite rotatory organ, a small muscle to move the foot, an oblique œsophageal head, with unequal jaws, two-toothed; a short œsophagus, simple intestine, with two spherical glands, a globular ovarium, a contractile vesicle, and a long ganglion.

M. *carinata* (*Trichodus rattus*, M.)—Lorica anteriorly crested on the back; foot the same length as body; it swims slowly, and resembles *Monocerca rattus*. Figs. 438, 439, are side views, showing the delicate ridge of the lorica projecting on the back, and fig. 440 a dorsal view. Found amongst Ceratophyllum. Length 1-72nd.

Genus Euchlanis. *The mantle Rotatoria.*—Eye single, cervical; foot furcate; lorica oval and flexible, longitudinally gaping upon the ventral surface. Compound vibratile muscles, with their cilia, compose the rotatory organ: the other muscles are those for moving the foot, and for manducation, and fibrous longitudinal ones, presenting transverse corrugations. An œsophageal head, with one or many-toothed jaws (perhaps four jaws in E. *macrura*), (*gymnogomphia*), a very short œsophagus, an alimentary canal (simple in five species, constricted in one), having two glands, compose the nutritive apparatus. An ovarium is observed in five; and two small glands, with a contractile vesicle, in two of the larger species. Two species have perhaps transverse vessels, and in the larger forms tremulous gills are observed, attached to the sexual glands; a respiratory tube is seen in E. *lynceus* only. All the species have a red-coloured cervical eye, which, in five species, is connected with a large ganglion. They do not carry about their eggs externally, nor are they developed in large numbers. Dujardin does not admit the genus *Monostylus*, but places its three species in the present one—Euchlanis.

E. (?) *triquetra.*—Lorica very large, trilateral, with a dorsal crest; setæ on foot none. This species is very diaphanous, and "therefore," remarks Ehrenberg, "I was never able to see the line of division on the ventral surface of the lorica; the relationship of the fibres of

the lateral muscles is physiologically and anatomically interesting: they form three bundles, on each side, and show as distinct corrugations as do the muscles of larger animals." Fig. 443 represents a fore-shortened view. Fig. 442 a left side view, shewing the dorsal crest of the lorica. At the base of the foot an external empty fold of the skin is visible. Fig. 441 exhibits the ventral surface, and an opening for the foot, but no division of the lorica is visible. Fig. 444 shows the teeth and jaws separate. Found in turf pools. Length 1-48th; ovum 1-192nd.

EUCHLANIS (?) *Hornemanni.*—Lorica thin, short, cup-shaped, truncate in front, the anterior part of the body soft (pliant) and elongated. This creature appears able to draw within the lorica both foot and head. Sometimes longitudinal muscles are apparent, and Ehrenberg has seen three delicate parallel transverse lines, which he states to be vessels. Length 1-432nd to 1-240th.

E. *luna* (*Cercaria luna*, M.)—Lorica cup-shaped, the front excised in a lunate manner, toes with claws. The single-toothed jaw, the constriction of the alimentary canal, and the claws, distinguish it from the other species. Found amongst Ceratophyllum and Conferva. Length 1-144th.

E. *macrura.*—Lorica large, ovate, depressed; bristles at the base of the foot; toes long, styliform. This species is distinguished from the following one by its stronger and longer toes. "Lately," says Ehrenberg, "I saw the division of the lorica along the ventral surface." Each jaw has five teeth, and there are two soft maxillary appendages, each with two teeth. Found amongst Conferva, in clear water. Length, without foot, 1-96th.

E. *dilatata* (*Brachionus*, M.)—Lorica broad, depressed, folded on the under side; foot without setæ; toes long. This animalcule, when it emerges from the egg, has a very soft lorica, and resembles *Notommata.* Length of lorica 1-96th.

E. *lynceus.*—Lorica ovate, turgid, deeply fluted; two little horns project anteriorly. Fig. 445 represents a back view, and 446 a side view; the lorica is open along the middle of the under side. Length of lorica 1-216th.

E. *deflexa* (Gosse)—Body semi-oval; ventral surface of the lorica divided longitudinally, and the edges of the fissure bent out at right

angles; foot furnished with two pairs of bristles; toes spindle-shaped. Lorica 1-80th.

EUCHLANIS *pyriformis.*—Outline of body (viewed dorsally) nearly oval, with a slight constriction in the middle; lorica divided longitudinally along the ventral surface, the gape widening anteriorly; toes parallel, edged; eye minute. Lorica 1-62nd.

E. *hipposideros.*—Body nearly oval in outline; the ventral side flat; the dorsal greatly arched, and ridged down the middle; lorica formed of two distinct plates; the dorsal plate enveloping the back and half down the sides; the ventral separated from it by a wide space, and hollowed in the middle, so as to present the figure of a narrow horse-shoe, whose points are forwards; foot armed with one pair of bristles. Lorica 1-110th.

Genus SALPINA.—*The Stock-fish Rotatoria.*—Eye single, cervical; foot furcate; lorica closed below, and terminated by spine-like processes or teeth. "The lorica," says Dr. Ehrenberg, "resembles a three-sided little casket, with arched sides, flat below, and having, anteriorly and posteriorly, at the truncated extremities, little points." The animalcule can entirely withdraw itself within the lorica. All the species have an elevated ridge upon the back, which in two species appears to be double. (Ehrenberg is somewhat inclined to think the lorica is open, its whole length, upon the dorsal surface.) A compound rotatory organ, two short anterior lateral, and two foot muscles, in S. *mucronata,* are seen, as locomotive agents. An œsophageal head, with three or four toothed jaws, a short œsophagus, and a simple conical alimentary canal, exist in all the species; in five species the conical intestine has two spherical glands. The ovarium is distinct. A respiratory spur or tube is observed at the neck in three species; the red eye in connexion with a cerebral ganglion is always present. They do not increase in large masses.

S. *mucronata* (*Brachionus mucronatus,* M.)—Lorica very minutely scabrous, anteriorly four and posteriorly three-horned; horns generally straight and of equal length. The lorica, when the creature is young, is soft and bent, but soon hardens, and produces horns. The spur, or respiratory tube, in the neck, terminates in a little bristle, as seen in fig. 450. In some specimens, Ehrenberg says, the lorica appears as if punctate or stippled. Figs. 447, 448, repre-

sent full-grown specimens, with the head withdrawn; the latter figure is a back view, the former an under one. Fig. 449 is a side view, head extended. Fig. 451 is an egg, just deposited on Lemna; fig. 452 an egg, with the young vibrating; and fig. 450 shows the young one just escaped from the shell; fig. 453 represents the teeth separately. Length of lorica 1-144th.

SALPINA *spinigera.*—Lorica horned, four frontal, three posterior horns; the posterior dorsal one longest, and a little recurved. Glands on the alimentary canal not observed. Found amongst Ceratophyllum. Length of lorica 1-140th.

S. *ventralis.*—Lorica stippled, horns two in front, three behind, the dorsal one short and decurved. Found amongst Conferva, &c. Length 1-120th.

S. *redunca.*—Lorica smooth, horns two in front, three behind, two of the latter (the under ones) hooked, the dorsal crest bifid and gaping; teeth four to each jaw. Found amongst Conferva. Length 1-200th.

S. *brevispina.*—Lorica scabrous, horns two (small) in front, and three behind, short dorsal crest not gaping; lorica milky and turbid, but appearing bright; respiratory tube unknown. Found amongst Ceratophyllum. Length 1-144th.

S. *bicarinata.*—Lorica smooth, horns four in front, three behind, short; neither lateral muscles nor respiratory tubes known. Length 1-216th.

Salpina spinigera, S. *ventralis*, S. *redunea*, and S. *bicarinata*, are considered as slightly variable forms of one and the same animal.

Genus DINOCHARIS.—*The goblet Rotatoria.*—Eye single, cervical; foot furcate, and lorica closed below, and unarmed at both ends. The compound rotatory organ has five or six muscles, and the foot two in two species. An œsophageal head, with single-toothed jaws, is found, except in D. *tetractis*, which Dr. E. thinks has four teeth; œsophagus very short, alimentary canal constricted, except in D. *pocillum (gasterodela)*, which is constricted: two oval glands exist in D. *pocillum* and D. *tetractis*. Glandular portions of ovarium are seen in all, and a contractile vesicle at the base of the foot in D. *pocillum*. Traces of a vascular system are perhaps to be seen in D. *pocillum*, though even here it is doubtful, for the apparent tremulous organ,

just behind the œsophagus, may be only a tremulous condition of an internal fold of the stomach. The only evidences of a nervous system are the eye and the long ganglion which supports it.

DINOCHARIS *pocillum* (*Trichoda pocillum*, M.)—Lorica nearly cylindrical; two long spines at the base of the foot; toes three; it has a slight dorsal ridge. Figs. 454, 455, represent this creature in different positions; and fig. 456 the œsophageal head. Found amongst Ceratophyllum, &c. Length 1-120th.

D. *tetractis.*—Lorica acute, triangular; horns two, at the base of the foot; toes two. This species has longer toes than the others and the body is comparatively shorter. Found with Lemna and Ceratophyllum. Length 1-120th.

D. *paupera.*—Lorica acute, triangular; horns two, at the base of the foot, scarcely perceptible; toes two, short. Length 1-120th.

Genus MONURA. *The styliform-footed Rotatoria.*—Eyes two, frontal; foot simple, styliform. The lorica is somewhat compressed and open upon the ventral surface: anteriorly is a hook-like process, which can be withdrawn. In one species the vibratile organ has four to six muscular bulbs; in both an œsophageal head, with two jaws toothed, a very short œsophagus, and a simple alimentary canal, with two spherical glands, are observed; an ovarium, with a single large ovum, and, in one species, the vesicle of the germ, have been seen. The eyes are red, moveable, and seated upon nervous masses. The species are not only difficult to distinguish from each other, but also from the genus *Colurus;* the toes of the latter appearing single until pressure is used.

M. *colurus.*—Lorica oval, obtuse, obliquely truncated posteriorly, eyes near to each other. Lorica 1-280th. Siberian specimens, 1-400th.

M. *dulcis.*—Lorica ovate, anteriorly acute, posteriorly obliquely truncate; eyes distant from each other; the alimentary canal is often filled with green matter. They increase rapidly in glass vessels. Figs. 457 to 459 represent three views of this animal. Found amongst Conferva. Length of lorica 1-288th.

The two species of *Monura* are referred by Dujardin to *Colurus*, or, to adopt his appellation, to *Colvrella.*

Genus COLURUS. *The pincer-footed Rotatoria* have two frontal eyes, a furcate foot, and a compressed or cylindrical lorica. The

lorica is open upon the under side *(scutellum)*; this is distinctly seen in four species; a compound rotary organ is present in all, over it projects a retractile frontal hook (respiratory tube); an œsophageal head with two jaws, in two species with two or three teeth; the œsophagus very short; two species have a constricted stomach *(gasterodela)*, the others have a simple alimentary canal *(cœlogastrica)*, all with glands. The red frontal eyes are delicate; in C. *uncinatus* and C. *bicuspidatus* they have escaped observation; all have peculiar vesicles at the back. They resemble *Monura*.

Colurus (?) *uncinatus* (*Brachionus uncinatus*, M.)—Lorica ovate, compressed, posterior and bi-pointed toes, very short; at the middle of the back is generally a circlet of vesicles, which at one time Ehrenberg considered eyes, but he now regards them as vesicles of oil, as they are seen in all the species, and abundantly in the *Cyclopida*. Found both in fresh and sea water. Length 1-430th to 1-288th.

C. (?) *bicuspidatus*.—Lorica ovate. compressed, the two points posteriorly strong; toes short. Length 1-288th.

C. *caudatus*.—Lorica ovate, compressed, posterior points distinct; toes longer than the foot. The shell resembles C. *uncinatus*, but the toes are much longer. Found both in fresh and sea water. Lorica 1-288th.

C. *deflexus*.—Lorica ovate, compressed; the shell is more rounded, and very transparent. Figs. 460 to 462 represent back, under, and side views; the former shews the vesicles. Found in the clear water of a peaty moor. Length 1-240th.

Genus Metopidia. *The frontal-eyed Rotatoria* have two eyes in front, a furcate foot, and a depressed or prismatic lorica; the frontal portion naked or uncinate (not provided with a hood); indeed they may be termed *Lepadella*, with two red frontal eyes; the lorica appears to be closed on the under side *(testula.)* In two species the rotary organ has from three to four muscles, and in one species two foot muscles are observed. Two species have a frontal hook (respiratory tube), like *Colurus*. The œsophageal head in one species has two, in another four, but in the third no distinct teeth; a short œsophagus, and two spherical glands, are present in all. Two species have a distinct constricted stomach *(gasterodela.)* An ovarium is present, and M. *triptera* has a contractile vesicle.

M. *lepadella*. — Lorica depressed, nearly flat, broadly ovate,

excised in a lunate manner in front, rounded posteriorly; toes somewhat longer than foot. This species resembles in form *Lepadella ovalis* (fig. 207) and *Squamella bractea*, but is distinguished from the former, which has two-toothed jaws and no eyes; from the latter, which has four eyes and indistinctly-toothed jaws. Figs. 463 to 465 represent different views of this animalcule—viz., back, under, and side, the first and last having the rotary organs extended and in motion. Length 1-240th.

METOPIDIA *acuminata*.—Lorica depressed, nearly flat, oval in shape; anteriorly slightly excised, posteriorly pointed. This species resembles *Colurus*, but in that genus the eyes are very close together, and the lorica open beneath. Found amongst Oscillatoria. (1-240th.)

M. *triptera*.—Lorica oval, triangular, back crested: a section would resemble fig. 443. Found amongst Conferva. (1-200th.)

M. *solidus* (Gosse.)—Much resembles M. *lepadella*, but is considerably larger; lorica circular, brilliantly transparent; a slight puncturing runs round near the edge, like the legend on a coin. Lorica 1-150th.

M. *oxysternon*.—Resembles M. *triptera*, but the dorsal keel is much higher and thinner; the anterior, two-thirds of the ventral surface, form a prominent ridge, terminating abrubtly, like the breast bone of a bird, and the posterior portion is hollowed out remarkably. Viewed laterally, the outline of the back is very gibbous behind. Lorica 1-175th.

Genus STEPHANOPS. *The diadem or coronet Rotatoria.*—Eyes two, in front; foot furcate; lorica depressed or prismatic; the front provided with a hood or diadem. The lorica, in two species, has thorn-like processes posteriorly. In one species a longitudinal muscle is observed on each side (anteriorly), two muscles for moving the foot, and from three to five belonging to the compound rotary organ. The œsophageal head has single-toothed jaws, and a short œsophagus. One species has a two-partite alimentary canal, the others a simple one; two species have glands; an ovarium exists in all; a contractile vesicle in two. The red eyes are situated on each side, near the frontal head in two species; in one they are yet unknown.

The hood remains extended, even when the creature withdraws within its shell.

Stephanops *lamellaris* (*Brachionus lamellaris*, M.)—Lorica with three spines posteriorly. The rapid movement and transparency of this animalcule renders its organization difficult to observe. Figs. 466, 467, represent different views with the crystalline hood or diadem. Found amongst Conferva. Length of lorica about 1-300th.

S. (?) *muticus*. —Lorica unarmed posteriorly, entire. Ehrenberg remarks it is active, and that he has not seen the eyes satisfactorily. Length 1-144th.

S. *cirratus* (*Brachionus cirratus*, M.) — Lorica with two spines posteriorly. This species has a contractile vesicle. Length 1-240th.

Genus Squamella. *The four-eyed Euchlanidota.* — Eyes four, frontal; foot furcate. The lorica is closed *(testula)*; the rotary organ consists of five or six muscular bulbs. In one species the œsophageal head has jaws, with two or three teeth each; its tube in one is short, in the other long, and bent like the letter S. Both have a two-partite intestine *(gasterodela)*, with small glands, also an ovarium and contractile vesicle. The eyes are disposed in pairs on each side the brow.

S. *bractea* (*Brachionus bractea*, M.) — Lorica depressed, broadly ovate. It is very transparent; the toes thick and short, not evident. Length of lorica 1-144th.

S. *oblonga*.—Lorica depressed, either elliptical or ovato-oblong, hyaline, toes long and slender; eyes larger than in the foregoing species. Figs. 468, 469, represent back and side views of this animalcule. Found in green-coloured water, with *Chlamidomonas pulvisculus*. Length of lorica 1-280th.

Family.—PHILODINAEA.

This family comprehends Rotatoria devoid of lorica, but possessing two simple rotatory organs, resembling wheels. The body of most species is worm-like, or spindle-shaped (fusiform.) Portions of the body can be thrust in and out, like the tubes of a telescope; this is effected by a sort of false joint, caused by a peculiar insertion of the muscles. In all the species the foot is furcate; and in *Callidina*, *Rotifer*, *Actinurus*, and *Philodina*, it is provided with soft processes, resembling, in shape, horns, near the false joints, as in the genus

Dinocharis (fig. 455.) Muscles are seen in the genera just named. The nutritive apparatus consists of an œsophageal head, with two jaws; in three genera these are double-toothed (*zygogomphia*); in two the teeth are in rows (*lochogomphia.*) In the four principal genera the alimentary canal is filiform; it is furnished with a bladder-like expansion at its commencement (*trachelocystea*), and surrounded by a turbid cellular or glandular mass. In one genus the alimentary canal is conical (*coelogastrica*), in the two African genera it is unknown. In four genera the intestine has glands; in a like number, an ovarium and glands are present; a contractile vesicle exists only in *Rotifer* and *Philodina*, which, together with *Actinurus*, are also sometimes viviparous. In *Rotifer* and *Philodina* portions of a vascular system are visible, in the form of from nine to twelve transverse vessels; the same genera, as also *Actinurus* and *Monolabis*, have spur-like respiratory tubes. In thirteen species red eyes are present, and beneath these organs only, is nervous matter apparent.

The genera are disposed as follows:

Eyes absent.	proboscis and foot processes present			Callidina.
	no proboscis or horn-like processes	rotary organ pedicled		Hydrias.
		rotary organ not pedicled		Typhlina.
Eyes present	two frontal	foot having horn-like processes	toes two	Rotifer.
			toes three	Actinurus.
		foot without horn-like processes, toes two		Monolabis
	two cervical			Philodina.

"The characters employed," says Dujardin, "by M. Ehrenberg, for the distinction of his genera of *Philodinæa*, have certainly too slight a constancy to be admitted; that author has himself seen the red specks, which he calls eyes, vary in number and position in his Rotifers. As to the appendages of the tail (toes), they are not always alike visible, although actually present, because the animal does not extend them except at certain moments; the central terminal appendage—that by which the Rotifers affix themselves to solid

bodies, is itself of greater or less length, but always present. We therefore think that but two genera can be rightly established; one, *Callidina*, characterized by the feeble development of its ciliated rotary organ, and by entirely wanting red specks; the other, *Rotifer*, with two or several red points placed more or less near the exterior extremity, and, what is of more importance, with very highly developed rotary organs."

"The genera *Hydrias* and *Typhlina* are founded on imperfect observations made by the author during his journey in Egypt; and the genus *Monolabis* ought to be placed elsewhere."

The family *Philodinæa* thus formed, is arranged parallel with *Brachionæa*, as though the absence of a lorica were the only difference between them.

So far as Dujardin accepts of the same species, his family *Rotifera* and that of *Philodinæa* of Ehrenberg correspond.

Genus Callidina. *The beautiful Rotatorial Animalcule.*—Characterized by wanting visual organs, and by possessing a proboscis, and a foot, furnished with processes resembling horns. The vibratile, or rotatory organ, is double, but not pedicled; anteriorly is a thickly ciliated proboscis. The furcate foot has two elongated toes, four little horns or processes, and six points. Two muscles for moving the foot are also visible. The œsophageal head has two jaws, with numerous delicate teeth. The filiform alimentary canal has a bladder-like expansion posteriorly, but is not provided with glands; it is surrounded by a granular and cellular mass, whose function is unknown; Ehrenberg thinks it connected with reproduction; an ovarium, with single large ova, is seen; a little spur-like process, projecting from the neck, may be a respiratory tube; no indication of a nervous system is observable.

C. *elegans*.—Body spindle-shaped, crystalline; rotatory organs, or wheels, small. Figs. 470 to 472 represent this animalcule in different states of extension or contraction. Fig. 473 shows the eggs. Found in bog water and infusions of oak bark. Length 1-72nd.

C. *rediviva* (Ehr.)—Body fusiform, diffusely granular or else fleshy; with red, distinct ova, and strong rotary organs. Length 1-60th to 1-48th. Of ova 1-576th. Berlin, in the sediment of water-spouts of houses.

Dujardin figures a species of *Callidina*, which he would name CALLIDINA *constricta*, on account of the contracted form of its rotary apparatus. Its jaws present a row of closely set parallel teeth. Length 1-52nd.

CALLIDINA *bidens* (Gosse.)—Body spindle-shaped, jaws furnished with two distinct teeth. Length 1-45th. Perhaps this is no other than Professor Ehrenberg's C. *elegans*, of which he describes the jaws as having many delicate teeth. I have, however, examined numerous specimens, and have always found them distinctly two-toothed.

Genus HYDRIAS. *The Water-turner* is African. It is devoid of eyes, proboscis, and the little horn-like processes at the foot; the two small rotatory organs, or wheels, are supported on pedicles or arms. An œsophageal head, and an ovarium, with a large ovum, have been seen by Ehrenberg. The form is like a naked *Pterodina*.

H. *cornigera*.—Body ovate, hyaline; foot attenuated, resembling a furcate tail. Fig. 474 represents an animalcule extended. Found with Oscillatoria, in standing water, from a small spring by Siva, in the Oasis of Jupiter Ammon. Length 1-190th.

Genus TYPHLINA. *The blind Vibrator*, like the last, is African. Devoid of eyes, proboscis, and horn-like processes at the base of the foot; but its little wheels are sessile. It resembles a very small *Rotifer*, without frontal proboscis or eyes.

T. *viridis*. — Body oblongo-conical, small: it is represented in group 475. Found by Drs. Hemprich and Ehrenberg in a pool near Cairo in Egypt, in such numbers as to colour the water green. Length 1-720th.

Genus ROTIFER. *The proboscised Rotatoria*. — Eyes two, placed upon the frontal proboscis; foot provided with little horn-like processes, and the two toes bisulcate at their apices. A double rotatory organ (considered by Cuvier, and others, as a respiratory apparatus), furnished with muscles, is seen in all the species; also longitudinal and foot muscles in three of them; a furcate foot and horn-like processes in four species; in R. *citrinus*, the pincer-like portions of the foot appear to be tri-pointed; in R. *erythraeus*, they were seen to be drawn in. In four species a muscular œsophageal head, with jaws, each two-toothed, is seen; in three species the alimentary canal is filiform, with a vesicular expansion at the extremity; it has no

œsophageal tube, but is surrounded by a cellular glandulose turbid mass; one species has a conical, tubular, alimentary canal, without the surrounding mass or expansion at the end; the four European species have two spherical alimentary glands, and an ovarium, with a few large ova; occasionally these species are viviparous. In three of them a contractile vesicle is present. In R. *macrurus,* near the alimentary canal, are two glands. In three species from nine to twelve parallel transverse vessels have been observed by Ehrenberg; and besides these, in the four European species, styliform respiratory tubes, emanating from the neck, which in one species are ciliated anteriorly. The indications of a nervous system are two red frontal eyes, in the four European forms; and beneath them, in R. *vulgaris,* are two ganglia.

Rotifer *vulgaris* (*Vorticella Rotatoria,* M.)—This creature, which was discovered by Leeuwenhoek, has a fusiform white body, gradually attenuated towards the foot; the eyes round. "This animalcule was described and illustrated in the *Microscopic Cabinet* some years ago, and prior to the appearance of Ehrenberg's observations. It has the power of contracting or extending the length of the body in the following remarkable manner:—When the creature is about to shorten itself, transverse folds or joints are observable, which do not appear to be confined in number or situation; the integuments, when a joint is produced, are drawn within the parts above, and slide out like the tubes of a telescope, when the joints disappear. It is this power that enables it to assume the form of a sphere, the head and tail being drawn within the body." Anteriorly it has a proboscis-like process, with a ciliated extremity, and a soft hook; near its end are two dark red points. The body terminates in a moderately-long tail-like foot, having six processes, disposed in pairs; two wreaths of cilia (the wheels), voluntarily moveable, are placed upon short thick arms (pedicled), which can be drawn in and out at pleasure; these wreaths serve for swimming and purveying, the food approaching the mouth by the currents produced in the water by the cilia. On the dorsal surface is a styliform horn (*Speculum collare,* M.) destitute of cilia at its end. During vibration the neck has a circular fold, appearing like lateral styles. Four longitudinal muscles, two anterior and two posterior, are seen; laterally, also, two club-shaped, for

moving the foot, and two belonging to the rotary organ. Sometimes, says Dr. Ehrenberg, four anterior longitudinal muscles, and a dorsal and ventral muscle appear to be present. It has two kinds of locomotion, one by alternately attaching the mouth and foot, and, as it were, stepping along; the other by swimming, from the action of the rotatory apparatus. If the creature attaches itself by the foot, and the rotatory apparatus is in motion, a strong current or vortex is produced on each side the wheels, resembling two spirals in the water, which bring the nutritive particles to the mouth, from which some are chosen, and the rest flow away. For observing this action with effect, finely divided carmine or indigo must be mixed in the water. The nutritive apparatus commences with a ciliated mouth, opening anteriorly, just beneath the hook-like proboscis; the cavity of the mouth is a long extensible tube, having posteriorly an œsophageal head, with four muscles, and two striated jaws with double teeth (*zygogomphia*). The œsophagus communicates with a filiform alimentary canal, which runs along the body, and has posteriorly an oval expansion near its opening, at the basis of the tail-like foot. A thick glandular cellulose mass, often yellowish or greenish, surrounds the alimentary canal; its use is unknown; Dr. Ehrenberg thinks it may be a cœcal appendage, or sexual glands; anteriorly are two biliary glands. The propagative system is very interesting; the ovarium is a globose glandular mass; in it four or five ova sometimes so completely develope themselves, that the young creep out of their envelopes, extend themselves, and put their wheels in motion while in it. They sometimes occupy two-thirds the length of the parent. In the ovum the young are coiled up in a spiral manner. A contractile vesicle exists, along with a vascular system, indicated by eleven or twelve parallel transverse vessels, and the respiratory tube at the neck. The latter was formerly considered a sexual organ. The two red frontal eyes, with ganglion beneath them, are evidences of a nervous system. These eyes are cells, filled with a granular pigment, and sometimes separate abnormally into several; so that Dr. Ehrenberg thinks no crystalline lens exists, but, it may be, they are compound, like the eyes of insects, to determine which will require a microscope possessing enormous penetrating power; a quality discovered by Dr. Goring, and amply explained and illustrated in

chapters xvi. and xvii. of the *Microscopic Cabinet.* Fig. 476 represents a full-grown animalcule extended, with the wheels vibrating, and the currents visible when indigo is put in the water; it is supposed to be attached to a fixed body. Fig. 477 is an under view of the same, with the wheels withdrawn, and the body contracted; fig. 478 is another, extended, but wheels withdrawn, which has, with figs. 479 and 480, which represent the upper portions more highly magnified, been submitted to different degrees of pressure between the plates of a compressor. In figures 476 to 478 ova are seen, some are developed, and their eyes and œsophageal bulb visible. The respiratory transverse vessels and tube, projecting from the neck, are seen in the engravings.

The following interesting observations of Dr. Morren, are extracted from the *Annals of Natural History*, vol. vi. :—

"The labours of the Rœper show that the cells of Sphagnum are sometimes furnished with openings, which place their interior cavity in communication with the air, or water, in which they are immersed. This skilful observer satisfied himself that, when circumstances are favourable, the *Rotifer vulgaris* exists in the cells of the Sphagnum obtusifolium. This grew in the air, in the middle of a turf pit, but Rœper observed its leaves in water; he does not mention whether the infusorial animalcule came from thence, or whether it was previously contained in the cavities of the cells. The general purport of the paper seems to imply that these Rotifers exist in the cells of that portion of the plant which was exposed to the air, and, in this case, the presence of an animal so complicated, living as a parasite in the cells of an aërial utricular tissue, is a phenomenon of the most curious kind in the physiology of plants, and the more so as this animal is an aquatic one.

"I recollected that the last year of my residence in Flanders, I found, near Ghent, the Vaucheria clavata, in which I observed something similar. M. Unger had already published the following details respecting this plant in 1828 :—' Beneath the emptied tubercles, and at several points of the principal stalk, at different angles, rather narrower branches are produced; these branches are generally very long, and greatly exceed the principal stalk in length. At the end of ten or twelve days after their development, there are seen, towards

one or the other of their extremities, here and there, at different distances from the summit, protuberances of a clavate form, more or less regular, straight, or slightly bent back; and others on the sides of the stalk, which have the form of a capsule, or vesicle. These vesicles are, at first, of a uniform bright green colour, and without increase of size, which exceeds several times that of the branches; they always become of a blackish-green colour, darker towards the base, and then one or two globules, of a reddish-brown, may be clearly distinguished there, often surrounded by smaller granules, evidently destitute of motion, whilst the great ones move spontaneously and slowly, here and there, in the interior of the capsule, by unequal contractions and dilatations, whence arise remarkable changes of form. I saw these globules at the end of eight or ten days after their appearance, still inclosed in the capsule, moving more and more slowly, receiving no very decided increase, whilst the base of the capsule became more transparent; at last I observed that, instead of their expulsion, which I was watching for, the extremity of the capsule, at the end of some days, took an angular form, and subsequently gave birth to two expansions, in the form of horns; it remained in this state, and became more and more pale, whilst the animalcule became darker, and died, and afterwards it ended by perishing at the same time as the other parts of the conferva.'

"Subsequent researches have not succeeded in informing us what this animal might be of which Unger spoke. As this author drew so much attention to the spontaneous movement of the propagula spores of the Vaucheria, and as he admitted the passage from vegetable life, characterized, according to him, by immobility, to animal life, the principal criterion of which was motion, his animalcule was confounded with the propagula; and no one, so far as I know, has returned to this very interesting subject.

"When, therefore, I found the Vaucheria clavata at Everghem, I was as much surprised as pleased to see the mobile body, noticed by Unger, better than he did: with the aid of a higher magnifying power, I found it easy to ascertain the true nature of the animal, for it was not a propagulum, but a real animal, the *Rotifer vulgaris*, with its cilia, wheels, tail, &c,

"The first protuberances, or vesicles, which I saw, containing this

animal, inclosed but one of them; afterwards they laid eggs, and multiplied; but it seems that then they descend the tubes of the Vaucheria, and lodge themselves in new protuberances, whose developement they may possibly stimulate, as galls and oak-apple s are organic transformations, attributable to the influence of parasitic beings.

"The *Rotifer vulgaris* travels quite at his ease in these protuberances; he traverses the partitions, displaces the chromule, and pushes it to the two extremities of the vesicle, so that this appears darker at these parts. One day I opened a protuberance gently; I waited to see the *Rotifer* spring out, and enjoy the liberty so dear to all creatures, even to infusorial animals, but no—he preferred to bury himself in his prison, descending into the tubes of the plant, and to nestle himself in the middle of a mass of green matter, rather than swim about freely in the neighbourhood of his dwelling.

"Some of these protuberances had greenish threads, appended to their free end, and others had none; I thought at first that these threads were some *mucus* from within, escaped through some opening which might have served the *Rotifer* as an entrance, but an attentive and lengthened observation convinced me that in this there was no solution of continuity, and that the arrival of the Rotifers in the Vaucheria was not at all to be explained in this way. How are these parasitic animalcules generated within them? This is what further research has some day to show. Meanwhile I have thought that it should be made known that the animalcule, found in the Vaucheriæ, by Unger, was the *Rotifer vulgaris* of Zoologists."

Found both in fresh and sea-water, in infusions, on the flocculent matters of water plants, &c Length 1-50th to 1-24th.

Rotifer (?) *citrinus.*—Body fusiform, lower part gradually attenuated into a foot; its horn-like processes elongated, eyes round, respiratory tube toothed. The extremities are transparent, the middle of the body of a citron colour; it often exhibits longitudinal folds, and is then less transparent. Found amongst Oscillatoria. Length 1-24th.

R. (?) *erythraeus.*—Body small, oblong, suddenly attenuated into a long foot. Length 1-240th.

R. *macrurus* (*Vorticella macrura*, M.)—Body transparent, ovato-oblong, suddenly attenuated into a long foot; this is distinguished from *Actinurus* by its small toes, horn-like processes, and suddenly-

attenuated body. The style, or respiratory tube, is ciliated in a star-like manner. The wheels are prominent, and it is altogether a choice subject for the microscope. Found in boggy water. Length 1-350th.

Rotifer *tardus.*—Body hyaline, fusiform, gradually attenuated to a foot, and having deep strictures in the form of square false articulations or joints; eyes oblong. It resembles internally R. *vulgaris.* Length 1-80th.

Of the several species of *Rotifer*, and of the following one of *Actinurus*, described by Ehrenberg, M. Dujardin confesses his inability to discover the specific differences, although he admits the differences of habitat, and of resistance to the process of dessication. He however believes he has discovered a *Rotifer* certainly specifically distinct from any variety of *Rotifer vulgaris ;* this he would designate

Rotifer *inflatus.*—Its form is less slender than R. *vulgaris,* its rotatory organs of less size, and its red specks seated very near the jaws. Length 1-58th. Found in water or wet moss.

Of this species he infers that Ehrenberg has constructed at least four others, according to the rose or yellow colour it presents, the form of the eyes, and the length of the caudal appendages, which are, to wit, *Philodina cryophalma*, P. *roseola*, P. *citrina*, P. *macrostyla.* At the same time he would regard P. *collaris*, P. *megalotrocha*, and P. *aculeata*, as distinct forms of *Rotifera.*

R. *macroceros* (Gosse.)—Wheels large ; antennal process (the respiratory tube) of Ehrenberg, very long and mobile. (1-100th.)

Genus Actinurus.—*The three-toed Rotatoria.*—Eyes two, frontal; foot furnished with two little horn-like processes, and three toes. In other respects the organization resembles *Rotifer vulgaris.*

A. *Neptunius* (*Vorticella Rotatoria*, M.)—Body white, fusiform, gradually attenuated into a long foot, having three equal toes exceeding the horn-like processes in length. The chewing action of the jaws in the œsophageal head is often distinctly seen. Fig. 481 represents this animalcule extended, with the wheels withdrawn, which is the case when crawling; the respirator tube is then seen, terminated by a single delicate hair-like point ; fig. 482 shews one contracted, but the head partially withdrawn ; fig. 484 represents the upper part, when the wheels are extended and in action ; fig. 483 the œsophagus and jaws, separated and extended under pressure. Length 1-36th to 1-18th.

Genus Monolabis.—These *Philodinean Rotatoria* have two frontal red eyes, and a foot with two toes, but no horn-like processes. They are provided with muscles for moving the double rotatory apparatus, two for moving the foot, and four belong to the œsophageal head and jaws, which last are furnished with double teeth, or teeth in rows. A very short œsophageal tube, and a simple conical alimentary canal, are seen in both species, one of them has two spherical biliary glands; an ovarium is seen in both, but in neither have fully-developed ova or male organs been observed. In one species, a respiratory tube is present.

M. *conica.*—Body stout, provided with a respiratory tube, or spur, and three teeth in each jaw. Between the rotatory organs the brow can project and resemble a proboscis. Figures 485, 486, represent different views from the under side. Length 1-120th.

M. *gracilis.*—Has a more slender body than the last, and two teeth in each jaw, but no respiratory tube or spur. Length about 1-200th.

Genus Philodina.—*The necked Rotatoria* have two cervical eyes, and horn-like processes to the foot. All the species possess two vibratile or wheel organs upon the breast, and five of them have a frontal ciliated proboscis. Longitudinal muscles are distinct in one species, and two for moving the foot in six. The œsophageal head has four muscles; its jaws are two-toothed in four species, three-toothed in two species; but in one species the œsophageal head has not been satisfactorily seen. The alimentary canal is filiform, with a posterior enlargement in six species; in one it appears to have pouches or pockets. The glandular or cellular mass surrounding the filiform part of the canal sometimes becomes distinctly coloured when the creature eats coloured food, and therefore seems connected with the nutritive system, and is probably a convolution of cœcal appendages. Biliary glands are found in six species. The ovarium developes eggs, but very seldom living young, hence they are only occasionally viviparous; three species possess a contractile vesicle; one, sexual glands. A respiratory tube at the neck is always present, in some cases it is ciliated. Transverse vessels are seen only in P, *erythropthalma.* Eyes are found in all the species, and nervous ganglia connected with them in P. *erythropthalma;* sometimes the eyes are very pale, hence a single specimen may be mistaken for *Callidina.*

PHILODINA *erythropthalma.*—White and smooth, eyes round, horn-like processes of the foot short, jaws two-toothed. This species is common, and found abundantly during the spring and summer in water tubs and amongst Conferva. In glass vessels it increases rapidly, and if supplied occasionally with two or three stems of hay, the breed may be preserved for years. It is often met with in vegetable infusions of different kinds; in these, however, it never originates, but only increases in number. Length 1-120th to 1-48th.

P. *roseola.*—Body smooth, eyes oval, horn-like processes of the foot short. "I have observed," says Ehrenberg, "that this animalcule, when kept in glasses, deposits its eggs in heaps, and the parent remains a long time with the young ones produced from them, forming a sort of family or colony, and which we are not to be hindered from ascribing to a *sense of company or family*, though the pride of man may laugh at it." Fig. 490 represents one with the wheels extended. Length 1-72nd to 1-48th.

P. *collaris.*—Is hyaline, or white, body smooth, eyes round, a prominent annulus or collar surrounds the neck. It is especially characterized by the extent of the alimentary canal, and cœcal appendages attached to it, so that, when the animalcule is fed upon indigo, it appears like a polygastric animalcule. Length 1-120th.

P. *macrostyla.*—White and smooth, with oblong eyes; it has three teeth in each jaw; horn-like processes of the base of the foot, long. Found amongst Oscillatoria. Length 1-70th.

P. *citrina.*—Body smooth, citron-coloured in the middle, extremities white, eyes variable in form, horn-like processes slightly elongated. Found amongst Oscillatoria. Length 1-70th.

P. *aculeata.*—Body white, provided with soft spines, eyes round. The respiratory tube is thickened anteriorly in a globose manner, the jaws have each three teeth. Figs. 487, 488, represent this animalcule; and fig. 489, the jaws and teeth separate. Length 1-70th.

P. *megalotrocha.*—White, body smooth and short, wheels large; the proboscis between them long, eyes oval, and the jaws two-toothed. Length 1-216th to 1-108th.

P. *hirsuta.*—Of a pale yellow colour, and covered by a short down; eyes oblong; foot prolonged by dorsal spines, viviparous. Length 1-72nd; of egg, 1-480th. Berlin.

FAMILY.—BRACHIONAEA.

The concluding family of the Rotatoria, *Brachionaea,* is distinguished by its members having two rotatory organs, and a lorica.

The lorica is a *testula,* and not a *scutellum.* The rotatory apparatus is often apparently composed of five parts, three central and two lateral. The latter alone constitute the rotatory organs, the others are only ciliated frontal portions, which during the vibration of the rotatory organs, remain stiffly extended as feelers. Some (perhaps all) have two setæ at the rotatory apparatus, as in *Synchaeta.* The genera *Noteus* and *Brachionus* have a forked foot, *Anuraea* is destitute of foot, and *Pterodina* has a suctorial disc at the end of the foot, but no toes. All the genera have jaws, with teeth attached to an œsophageal head, having four muscles. In *Pterodina* the jaws are partly two-toothed and the teeth in a line (*zygogomphia lochogomphia*), in the other genera they are many-toothed *(polygomphia.)* In *Noteus* and *Pterodina,* the alimentary canal is constricted, forming stomachs (*gasterodela*) ; in the rest it is partly simple (*coelogastrica*), partly with stomachs. Biliary glands have been observed in all the genera, as also an ovarium, male glands, and contractile vesicle. Many species of *Anuraea, Brachionus,* and *Noteus,* carry their eggs attached to them, after expulsion. In all the genera, except *Pterodina,* internal tremulous gill-like organs, attached to the glands, have been observed ; respiratory tubes exist in some species of the genera *Anuraea, Brachionus,* and *Noteus.* A nervous system is indicated by the presence of red visual points in all, except *Noteus,* which, however, possesses a cerebral ganglion,

Some of the *Brachionaea* may become so numerous, as to render the water milky and turbid.

The genera are disposed as follow :—

Eyes absent, with a furcate foot			Noteus.
Eyes present	one (cervical) eye	no foot	Anuraea.
		foot furcate	Brachionus.
	two frontal eyes, foot styliform		Pterodina.

Genus Noteus. *The egg-carrying Brachionaea* are destitute of visual organs, but provided with a furcate foot (*Brachioni* wanting eyes.) The two-wheeled vibratory organ has between its portions a three-lobed ciliated brow, but has no long feeler bristles; it possesses (as also the furcate foot), distinct muscles. The lorica has spines both anteriorly and posteriorly; an œsophageal head, with jaws, having many teeth (*polygomphia*), a constricted alimentary canal or stomach (*gasterodela*), with two large glands; an ovarium, two sexual glands, and a contractile vesicle, are to be recognized. There is also a trace of tremulous gills, a short and thick respiratory tube, and a large central ganglion, lying between the muscles of the vibratory organs. The absence of eyes Dujardin considers insufficient to constitute this genus, apart from *Brachionus.*

N. *quadricornis.*—Lorica sub-orbicular, depressed, rough (scabrous), and urceolated; it has anteriorly four horns, posteriorly two spines. This animalcule is large, very transparent, and of a whitish colour. Figs. 491 to 493 represent dorsal, ventral, and side views; and fig. 494 the jaws separate, and under pressure. Found amongst decayed sedge-leaves and Oscillatoria. Length 1-120th to 1-72nd.

Genus Anuraea.—Includes *Brachionea* having a single cervical eye, but no foot (*Brachioni* without feet.) In seven species the lorica has facettes upon the back, in four longitudinal lines: in three it is smooth; in thirteen species it is spinous anteriorly; and in seven posterierly also. A. *biremis* has a moveable spine on each side: one species is found as an empty shell only; in the rest rotatory organs, with their cilia, as often also their muscles, are seen; but no longitudinal muscles have been observed in any of the species. Jaws and teeth are seen in nine species. Alimentary canal constricted (*gasterodela*) in four; simple and conical (*coelogastrica*) in nine. They have two biliary glands at the commencement of the alimentary canal; an ovarium is seen in twelve species, but sexual glands and a contractile vesicle only in one of the larger and smooth species, in which also four tremulous gill-like organs are found. In three species respiratory tubes emanate from the neck. The eye, which is always present, indicates the existence of a nervous system. In A. *squamula,* A. *curvicornis,* A. *biremis,* A. *striata,* and A. *foliacea,* nervous matter is seen below it. Eight species have their eggs attached to them

after they are expelled. They swim freely, though not very quickly.

This genus has the name of *Anourella,* given it by Bory St. Vincent, retained by Dujardin.

(*a.*)—*Species posteriorly devoid of spines and pedicle.*

ANURAEA (?) *quadridentata.* — Lorica oblong, with four horns anteriorly, its posterior end obtuse, back tesselated. Length 1-216th, without the horns.

A. *squamula* (*Brachionus squamula,* M.)—Smooth, obtusely square, with six horns in front, obtuse behind. Figs. 495 to 497 represent different views of this animalcule, the two latter with an egg attached. Length 1-240th.

A. *falcata.*—Oblong, has six spines anteriorly, the two central ones curved outwards, like sickles. Surface of the lorica not ridged, but rough, posterior extremity obtuse. Length 1-144th.

A. *curvicornis.*—Nearly square, with six frontal horns, the two middle ones larger, and curved outwards and downwards. Dorsal surface tesselated; its large red round eye is seated upon a large nervous ganglion; the œsophageal head has three-toothed jaws. This animalcule also carries the eggs attached. Length 1-216th.

A. *biremis.*—Linear and elongated, with four horns anteriorly; back very smooth, and having two lateral spines, like oars. The œsophageal head has three-toothed jaws. Found in phosphorescent sea water. Length 1-144th.

A. *striata* (*Brachionus striata,* M.)—Linear and elongated, with six horns in front, the back with twelve longitudinal flutings or rays, and obtuse at the end. This species is very changeable in form, owing to the membranous lorica yielding to the contraction of the body, hence it is sometimes long, at others short, sometimes urn-shaped, bell-shaped, and even almost disc-shaped; the first, however, seems to be the normal form. Found in fresh and salt water. Length 1-130th.

(*b.*)—*Spinous, or attenuated in pedicle-like manner posteriorly*

A. *inermis.*—Lorica oblong, attenuated and truncated posteriorly; no spines anteriorly; back furnished with faint longitudinal rays. Found in peat water. Length when extended, 1-144th.

A. *acuminata.*—Lorica oblong, attenuated and truncated at the

posterior extremity, having anteriorly six sharp-pointed horns or spines, twelve longitudinal rays on the back. Found amongst Conferva. Length about 1-120th.

ANURAEA *foliacea.*—Lorica oblong, six spines anteriorly, posteriorly terminating in a spinous manner, like a pedicle, dorsal and ventral surfaces longitudinally striated, frontal region rough. It has four-toothed jaws, and a central ganglion below the eye. Length 1-180th.

A. *stipitata* (*Brachionus.*)—Lorica nearly square, or triangular, anteriorly six spines; posterior pointed like a pedicle, the back tesselated. Fig 498 represents a dorsal view, with the wheels extended. Length about 1-200th.

A. *testudo.*—Lorica square, having anteriorly six straight spines, all nearly the same length, and posteriorly a short one at each corner. The upper and under surfaces are rough, the former tesselated like *Noteus.* Length about 1-200th.

A. *serrulata.*—Lorica ovate, square, with six unequal spines anteriorly, the two middle ones long and curved; it has two short spines at the posterior angles, which are sometimes scarcely apparent. The surfaces are rough, and the dorsal also tesselated, like the preceding species. Independently of the two wheels, the brow has three cylindrical ciliated processes, truncate at their extremities. Length 1-216th.

A. *aculeata* (*Brachionus quadratus,* M.)—Lorica square, with six spines anteriorly, the two middle longest; at the posterior angles are two long and equal spines; back rough and tesselated, under side smooth. At the brow, between the two wheels, is a single ciliated frontal process; a little respiratory tube is situated in front of the eye. Length 1-144th; including the spines, 1-96th.

A. *valga.*—Lorica nearly square, with six spines anteriorly, the two middle ones the longest: at the two posterior angles is a spine of unequal length; dorsal and ventral surfaces rough, the former tesselated. The jaws are five-toothed, the red eye oval, its longer axis transverse. Length, without the spines, 1-210th.

The following species are given by Mr. Gosse (Annals Nat. Hist., vol. 8, 1851.)

A. *fissa* (Gosse.)—Lorica smooth, hyaline, swollen at the sides

and at the back; flattish on the belly, truncate in front, without any spines, attenuated and truncate posteriorly. There is a deep fold running down each side, or else the ventral plate is distinct from the dorsal; the ventral is also cleft through its medial line; eye very large, pale. Length 1-220th.

Anuraea *tecta* nearly agrees in form with A. *curvicornis*, but the posterior extremity is rather more pointed, and the tesselations are different; being larger and arranged on each side of a menial dorsal ridge, which gives to the back the form of a vaulted roof. Length 1-200th.

A. *brevispina* nearly agrees with A. *aculeata*, but the posterior spines are very short; the frontal spines are much less curved forwards; the surface is not punctated; and it is colourless. Length 1-146th.

A. *cochlearis.* — Lorica spoon-shaped, with six spines in front; the medial pair curving strongly forwards; posterior extremity attenuated into a long slender spine, inclined forwards; back ridged and tesselated, as in A. *tecta.*

Genus Brachionus.—*Brachionaea* which have a single cervical eye and a furcate foot. In all the species the lorica is a closed shell, with two openings like a tortoise-shell (*testula*), the margin of the anterior opening dentate, as is also, sometimes, that of the posterior. In B. *Bakeri* and B. *militaris*, the lorica is rough, and in the former tesselated; in all the other species it is smooth; the animalcule can completely withdraw itself within its lorica. The locomotive organs consist of a double rotatory apparatus, and a wrinkled and very flexible furcate foot. Between the rotatory organs are from one to three frontal processes, which are provided with long cilia or feeler-like hairs; between these processes, in six species, are from two to four long styles or bristles. The rotatory organs, when not completely extended, sometimes appear as if two or three-lobed. In all the species, from two to eight internal muscles, for moving the vibratory organs, are observed; also two foot muscles; and in six species from two to eight internal longitudinal ones. The digestive system comprises a large muscular œsophageal head, with two many-toothed jaws, (mostly five, but in B. *polyacanthus* four-toothed); a short œsophagus, and a constricted alimentary canal *(gasterodela)*;

except in B. *militaris*, where it is simple and conical *(coelogastrica)*; and two biliary glands, variously modified in form, present in all. Seven species exhibit glands, a contractile vesicle, and an ovarium; in the others, their roughness precludes those organs being satisfactorily perceived. No species is viviparous. All of them carry their eggs attached, often as many as eight or ten at a time. B. *pala* allows the eggs of another creature to be attached to its back, which it carries about until the young creep out. Traces of a vascular system are indicated in all by the presence of a respiratory tube in the neck; in B. *pala* are transverse vessels, and in four species from six to eight tremulous gill-like organs are attached to the sexual glands Of the nervous system, the chief ganglion, that beneath the red eye, is distinct in all. In four, the pigment of the eye is inclosed in a sharply four-cornered cell (as in Cyclops), of apparently two cells connected together laterally. In the cell the pigment is variously distributed, so that, in a physiological sense, there is no lens or cornea. In B. *pala*, B. *urceolaris*, and B. *rubens*, sometimes increase in such quantities as to render the water milky and turbid. Several species are infested with *Vorticella*, *Epistylis*, and other parasites, which attach themselves to their shells.

Brachionus *pala*.—Lorica smooth, with four spines in front, and two obtuse ones near the opening for the foot. This creature swims in a perpendicular position, the brow being directed upwards. Each jaw has five teeth; the alimentary canal, being constricted, forms a stomach. Length 1-36th; lorica only 1-48th.

B. *amphiceros*.—Has a smooth lorica, with four spines, both in front, and posteriorly; four sharp posterior teeth are characteristic. Length 1-72nd.

B. *urceolaris* (*Brachionus urceolaris*, M.)—Whitish, lorica smooth, with six very short spines in front, posterior extremity rounded; lorica slightly granulated; its points are shorter and less sharp than in the following species; delicate longitudinal ridges proceed from the spines; the jaws have each five teeth. Both sexual glands and contractile vesicle, as well as an ovarium, are seen. Found in fresh and brackish water. Length 1-96th to 1-72nd.

B. *rubens* (*Brachionus urceolaris*, M.)—Lorica smooth, with six

sharp spines in front, posteriorly rounded; the body is red. Length 1-50th.

Brachionus *Mülleri*. *Müller's Brachionus.*—Lorica smooth, with six obtuse spines in front, two short ones behind, resembling papillæ. This species is somewhat larger than B. *urceolaris*, and has peculiarly-shaped frontal spines. The margin of the chin (brow) is smoothly truncate, with three faint indentations. The lorica is very transparent. Length 1-60th.

B. *brevispinus*.—Lorica smooth, having six acute unequal spines in front, and four stout spines posteriorly, the two inner ones short; two sexual glands and a contractile vesicle are present. Found in slow running clear water, with Conferva, Length 1-65th.

B. *Bakeri* (M.)—Lorica rough, its middle tesselated on the dorsal surface; six unequal acute teeth anteriorly, two elongated (lateral and dorsal) spines posteriorly, and short ones at the sheath of the foot. The lorica is covered with delicate granules; those upon the middle of the ventral surface are arranged in parallel but somewhat curved lines. Length 1-120th to 1-60th.

The following interesting observations as to the development of this species, have been communicated to me by a friend, an accurate and diligent observer of nature. "About two o'clock, B. *Bakeri* was observed with one egg placed externally between the two posterior spines of the shell, and another small egg in the left side of the animal, which increased much in size in the course of the day. At nine in the evening, a motion was perceived in the exterior egg, like that of the muscular œsophagus of the parent; and about this time the internal egg was protruded and placed by the side of the other, being longer than it. At eleven, the young *Brachionus* burst with a bound from the egg in which the motion was perceived, and affixed itself by its tail to the lunette. At first it had the appearance of an oblong ball; by degrees, the anterior part spread, and the wheel processes were developed. Soon after, the posterior shell processes were visible in a semilunar shape, with the points nearly touching each other, which gradually expanded. The shell of the egg remained attached to the parent in the same position, quite transparent, with a longitudinal split through the whole length." (Brightwell, op. cit.)

BRACHIONUS *polyacanthus* (M.)—Lorica smooth, having anteriorly four long dorsal teeth or spines, six short ones at the margin of the chin. (ventral), and, posteriorly, five dorsal spines, the two external or lateral ones very long. Figures 499 to 501 represent dorsal, side, and under views of this animal; the first having the wheels extended, and the side view showing the respiratory tube and an ovum attached. (Length, without spines, 1-110th.)

B. *militaris.*—Lorica rough (scabrous), with twelve long and nearly equal spines anteriorly, and four posteriorly; the two middle ones unequal, and shorter than those of the preceding species. Length, without spines, 1-120th.

B. *Oon* (Gosse.)—Lorica ovate, the back swelling with an uniform curve, by which it is distinguished from B. *pala*, which is truncate or slightly cavate posteriorly; anterior spines four, straight, wide at the base, and pointed; the occipital pair taller than the lateral. Lorica 1-125th.

B. *dorcas.*—Lorica ovate, or sub-conical occipital edge, with four long slender spines, the middle pair curving forwards, and bent first from, and then towards each other, like the horns of an antelope; mental edge undulated, with a notch in the centre. Lorica 1-60th.

B. *heptatomus.*—Lorica ovate, recipital edge cut into six saw-like teeth, much shallower than in B. *Mülleri*, with the central notch deeper and rounder than the rest; mental edge with four rounded lobes, separated by notches; posterior extremity with two nipple-like points, biliary (or pancreatic) glands very large, and cleft into two lobes almost to their base; hence the name (heptatomus—seven cleft.) Lorica 1-103rd. In sea-water, mouth of the Neeze, Essex.

B. *angularis.*—Lorica hexagonal-oval, in a dorsal aspect; occipital edge with two small teeth, divided by a rounded notch (in some specimens there are obsolescent traces of a lateral pair); mental edge slightly undulated, sometimes with two low points, divided by a notch like the occiput, but still more faintly; posterior extremity with two short, blunt, well-marked processes. The general surface is roughened with angular ridges, and is sometimes sub-opaque and brown. Lorica 1-200th. This curious species has relations with *Noteus* and with *Pterodina*.

Genus PTERODINA. *The winged Rotatoria* include *Brachionaca*,

which have two frontal eyes, and a simple styliform foot. All the species have a smooth, flat, and soft lorica, like a tortoise-shell (*testula*); curved at the margin. A double rotatory apparatus, a simple conical foot, having a suction disc at the end, and sometimes cilia, are common to all. P. *elliptica* alone has a hairy frontal process between the wheels. Transverse or longitudinal muscles exist in all the species. The four-muscled œsophageal head has jaws, with teeth in rows in two species (*locogomphia*), and double-toothed (*zygogomphia*) in P. *elliptica;* the alimentary canal is constricted (*gasterodela*), and possesses, anteriorly, two glands; an ovarium is also seen in all the species. Sexual glands and a contractile vesicle are present in P. *patina.* No evidences of a vascular system have been discovered, and two red frontal points (probably eyes) are the only indications of a system of sensation.

Pterodina *patina* (*Brachionus patina,* M.)—Lorica membranous, orbicular, and crystalline, slightly scabrous near the broad margin, and excised anteriorly between the wheels. This species is very delicate and transparent. Fig. 502 represents a side view, and figs. 503 and 504 under views; the latter having the wheels extended, the former having them withdrawn, and the anterior margin bent in, so that the eyes appear near the middle of the lorica. Found in summer, among Lemna and Ceratophyllum. Length about 1-120th.

P. *elliptica.*—Lorica membranous, elliptical, with a narrow, smooth margin, front entire (not excised). The two wheels united by a brow furnished with setæ. Eyes distant. Found amongst Conferva. Length 1-120th to 1-108th.

P. *clypeata* (*Brachionus clypeatus,* M.)—Lorica membranous, oblong, narrow, smooth at the margin; there is a frontal portion, or brow, connecting the two wheels, but no setæ. The eyes approximate. Fig. 505 a dorsal view, with the wheels extended. Found in seawater. Length 1-120th; the shell, 1-144th.

The next genus, *Pompholyx,* instituted by Mr. Gosse, is considered by him a member of this family *Brachionæa.*

Genus Pompholyx. (Gosse.) (Ann. Nat. Hist., vol. 8, 1851.)—Two frontal eyes; foot wanting; rotatory organ double in the rear, entire in front; eggs attached behind after deposition. The

name alludes to the resemblance of the lorica to a round flat smelling-bottle.

Pompholyx *complanata*.—Lorica much depressed, nearly circular, with the lateral edges rounded; anteriorly truncate; occipital edge gradually rising to a central blunt point; mental ridge with two rounded lobes, divided by a central notch. Lorica 1-300th.

Of the ensuing genera, established by Ehrenberg, we have only met with the description of species; of one, indeed, with only a sketch of its relations.

Genus Larella, (Ehr.)—The following species of this new genus, the characters of which we have not met with, is named by Ehrenberg,—

L. *Piscis*.—Body with equal setæ, and three long fine hairs placed on each side the mouth, with two frontal eyes. Length 1-190th to 1-280th. Berlin.

Werneck has also seen this species.

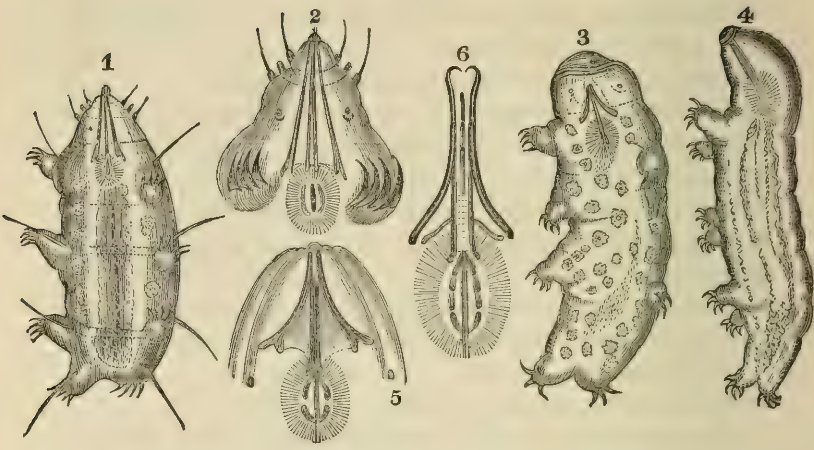
Genus Tetrasiphon, (Ehr.)—We have not met with the detail of the generic characters; but they may be gathered from the description of the following species:—

T. *Hydrocora*.—Very large, hyaline, with two prominent tubular occipital organs, and other two near the termination of the back; pancreatic glands, four, globose; jaws bidentate, with the oblique rotatory organ of *Pleurotrocha*. Foot with slender, long, and acute toes; eye occipital. Length 1-36th and upwards. Berlin.

Genus Dipodina, characters unknown.

D. *artiscon* (Ehr.) (Mentioned in Reports of Zoology, Ray Society.) Approaches *Notommata*, but differs by a particular constriction of its tarsal nippers (toes). Found by Ehrenberg, at Wismar, on the Baltic.

Class III.—TARDIGRADA.



TARDIGRADA, OR LITTLE WATER BEARS.

Figure 1.—*Emydium*, magnified 130 diameters. Figure 2.—Head of the same, magnified 300 times. Figures 3, 4. —*Tardigrada* magnified 160 times. Figure 5. — Head of same, magnified 300 times. Figure 6. — Mouth apparatus of *Macrobiotus*, greatly magnified.

The creatures named above, are introduced here as a class, inasmuch as they cannot be included with the Rotatoria. Some remarks on their organization will be found in Part I. of this work; and here I shall introduce further particulars, chiefly from my work of 1834, page 182, and from that of Dujardin's (*Hist. des Infusoires* p. 661.) They have oblong bodies, contracting into a ball; furnished with four pairs of short feet or mammilliform processes, each terminated by simple or double hooked claws; mouth very narrow, syphon-shaped; with an internal maxillary apparatus composed of two lateral moveable pieces, and of a strong muscular œsophageal bulb, furnished with horn-like dental articulated processes

The *Tardigrada* on the one side stand between the Rotatoria (Systolides Duj.) and the Helminthides; and on the other, the Annelida and Arachnida.

These creatures are usually found attached to aquatic plants, which float upon still water. I first obtained them from ponds in the Regent's Park. By placing some water with the plants in a common white hand-basin, and shaking the vegetation, they are detached, and fall to the bottom of the basin, from whence they are readily taken They are generally met with, in company with the larger kinds of Rotatoria, in moss. They are very sluggish in their movements, and are commonly known under the name of "little water bears." Under the polarizing microscope, the manducatory apparatus exhibits the same appearance as horn. They are capable of resuscitation after being dried. They vary in length from the 1-20th to 1-50th of an inch.

M. Doyère, in an elaborate Memoir in the Annales des Sciences, has divided the Tardigrada into four genera:—

Genus Emydium.—Body oval, anterior part narrow, and terminating in a pointed mouth, near to which, on each side, are flesh-like papillæ. Feet armed with four distinct claws; colour reddish. Found among moss (Bryum). Figures 1 and 2.

Genus Macrobiotus.—Body more cylindrical; obtuse anteriorly; no setæ; each foot furnished with two claws. Found with the preceding; also in rivulets (see figure 6.)

Genus Tardigrada.—Body stout, oblong; mouth not so sharply pointed. Found in stagnant water, on aquatic plants, and on the Hypnum fluitans. (See figures 3, 4, and 5.)

Genus Milnesium.—Characters unknown.

For further particulars consult Ann. des Sciences, t. 14, p. 269.

LIST OF PAPERS ON INFUSORIA AND ALLIED ORGANISMS,

Published in the Annals of Natural History, and referred to in the preceding pages.

On the Existence of Infusoria in Plants, by Professor Morren, vol. vi., p. 344, Jan. 1841.

On Plants and Animals found in the Sulphureous Waters of Harrowgate and Askern, by Dr. E. Lankester, vol. vii., p. 105, April, 1841.

On Red and Green Snow, by Prof. Meyen, vol. vii., p. 245, June, 1841.

On the Sacculi of the Polygastrica, by Dr. J. W. Griffith, vol. xi. p. 438, June, 1843.

On the Production of Infusoria in the Stomachs of Herbivorous and Carnivorous Animals, by M. M. Gruby and Delafond, vol. xiii., p. 154, Feb. 1844.

On Microscopic Life in the Ocean, by Professor Ehrenberg, vol. xiv., p. 169, Sept. 1844.

Abundant Occurrence of Rare Infusoria in the Scallop, by H. Lee, vol. xv., p. 371, May, 1845,

Microscopical Examination of the Chalk and Flint of the South East of England, by Dr. Mantell, vol. xvi., p. 73, Aug. 1845.

On the Organization of the Polygastric Infusoria, by C. Eckhard, vol. xviii., p. 433, Jan, 1847.

On Conjugation in the Diatomaceæ, by G. H. K. Thwaites (with a plate), ditto (with two plates) vol. xx., p. 9, July 1847. Vol. xx, p. 343, Nov. 1847.

On the Siliceous Polycystina of Barbadoes, by Professor Ehrenberg (with two plates), vol. xx., p. 115, Aug. 1847.

Here Commences the New Series of the Annals.

On the British Lagenæ (with two plates), by W. C. Williamson, vol. i., p. 1, Jan. 1848.

On the Diatomaceæ (with two plates). by G. H. K. Thwaites, vol. i., p. 161, March 1848.

On a new British Species of Campylodiscus, by W. C. Williamson, vol. i, p. 321, May, 1848.

Notes on Diatomaceæ, by Professor Dickie, vol. i., p. 322, May, 1848.

On Fossil Diatomaceæ in Aberdeenshire, by Professor Dickie, vol. ii., p. 93, Aug. 1848.

On a Diœcious Rotifer, by T. Brightwell (with a plate), vol, ii., p. 153, Sept. 1848.

On the Colour of a Freshwater Loch, by Professor Dickie, vol iii., p. 20, Jan. 1849.

On the Mode of Growth in Oscillatorieæ, by J. Ralfs, vol. iii., p. 39, Jan. 1849.

Observations on Recent Foraminifera, by W. Clark, vol. iii., p. 380, May, 1849.

On two new Species of Floscularia, by Dr. W. M. Dobie (with a plate), vol. iv., p. 233, Oct. 1849.

On the Development of Trichodina pediculus, (?) by J. T. Arlidge (with a plate), vol. iv., p. 269, Oct. 1849.

On the Conjugation of Closterium Ehrenbergii, by the Rev. W. Smith (with a plate), vol. v., p. 1, Jan. 1850.

On Deposits of Diatomaceous Earth on the Shores of Lough Morne, County Antrim, by the Rev. W. Smith, vol. v., p. 121, Feb. 1850.

On Nyctotherus, a new genus of Polygastrica, by Dr. Leidy, vol. v., p. 156, Feb. 1850.

On the Recent Foraminifera by W. Clark, vol. v., p. 161, March, 1850.

On the Nostochineæ, by J. Ralfs (with two plates), vol. v., p. 321, May, 1850.

On Asplanchna priodonta, by P. H. Gosse (with two plates), vol. vi., p. 18, July, 1850.

Notes on the Diatomaceæ, with Descriptions of the British species included in the genera Campylodiscus, Surirella, and Cymatopleura, by the Rev. W. Smith, (with three plates) vol. vii., p. 1, Jan 1851.

On three new species of Animalcules, by J. Alder, vol. vii., p. 426, May, 1851.

On the Germination of the Spore in the Conjugatæ, by the Rev. W. Smith, vol. viii., p. 302, Dec. 1851.

On the cell-membrane of Diatomaceous Shells, by J. W. Bailey, vol. viii., p. 157, Aug. 1851.

Remarks on Dickieia, by J. Ralfs, (with a plate) vol. vii., p. 204, Sept, 1851.

Catalogue of the Rotifera found in Britain, with descriptions of five new genera, and thirty-two new species, by P. H. Gosse, vol. viii., p. 197, Sept. 1851.

On Chantransia, by J. Ralfs. vol. viii., p. 302, Oct. 1851.

Notes on the Diatomaceæ, with Descriptions of the British Species, included in the genus Pleurosigma, by the Rev. W. Smith, (with two plates) vol. ix., p. 1, Jan. 1852.

N.B. The papers of Mr. Ralfs, which appeared before the publication of his work on *British Desmidieæ*, are omitted.

DESCRIPTION OF THE ENGRAVINGS.

NOTE.—The figures represent magnified views; the generic and specific characters will be found in Part III, by reference to the index.

PLATE I.

Group 1. Monas crepusculum
2. ——— punctum
Cluster 3. and figs. 4, 5, 6, Uvella glaucoma
Figures 7 to 11. Polytoma Uvella
12 to 14. Microglena monadina
15 to 17. Glenomorum tingens
Group 18. Doxococcus ruber
19. Chilomonas paramecium
20. Bodo intestinalis
Figures 21, 22, 23. Cryptomonas ovata.
24, 25. Prorocentrum micans
26, 27, 28. Lagenella euchlora
Group 29. Cryptoglena conica
Figures 30 to 33 Trachelomonas volvocina
34. Gyges granulum
35 to 37. Pandorina morum
38 to 42. Gonium pectorale
43. ——— ? tranquillum
44 to 46. Syncrypta volvox
47. Eudorina elegans
48, 49. Sphaerosira volvox
50, 51. Synura uvella

Group 52. Chlamidomonas pulvisculus
Figures 53, 54. Uroglena volvox
55 to 57. Volvox globator
Group 58. Bacterium triloculare
59. Vibrio bacillus
Figure 60. Spirochaeta plicatilis
61. Spirillum undula
62. Spirodiscus fulvus
63 to 65. Closterium acerosum
66. ——— turgidum
Group 67. ——— setaceum
Figure 68. Astasia haematodes
69. ——— pusilla
70. Amblyophis viridis
71 to 73. Euglena sanguinea
Group 74. ——— pyrum
Figures 75, 76. ——— longicauda
77. ——— triquetra
Group 78. ——— acus
79. Chlorogonium euchlorum
80. Colacium ? vesiculosum

PLATE II.

Group 81. Distigma proteus
82. Epipyxis utriculus
Figures 83, 84. Dinobryon sertularia
85 to 87. Amœba princeps
88, 88* ——— radiosa
89 to 91. Difflugia proteiformis
92 to 94. Arcella aculeata
95 to 98. Cyphidium aureolum
Group 99. Desmidium hexaceros
Figs. 100, 101. Staurastrum dilatatum
102, 103. ——— paradoxum
104. Pentasterias margaritacea
105, 106. Tessarthra moniliformis
107. Odontella ? filiformis
108. ——— desmidium

Figs. 109. Xanthidium aculeatum
110. ——— furcatum
111. ——— ? difforme
112, 113. Arthrodesmus convergens
114. Micrasterias heptactis
115, 116. ——— Boryana
117, 118. ——— Napoleonis
119, 120. Microtheca octoceros
121 to 123. Euastrum rota
124. ——— crux melitensis
125. ——— verrucosum
126. ——— margaritiferum
Group 127. Pyxidicula operculata
Figs. 128. Gallionella lineata
129, 130. ——— ferruginea

PLATE III.

Group 131. Gallionella sulcata
*131. ——— varians
132. Actinocylus senarius
Fig. 133. to 136. Navicula viridis
137, 138. ———striatula
Group 139. ———Phœnicenteron
Fig. 140. ——— ? pellucida
Group 141. ———amphisbaena
Fig. 142. ———platystoma
143. ———nodosa
144. ———Baltica
Group 145. ———hippocampus
146. ———sigma
147. ———acus
148. ———sigmoidea
149. ———? undulata
Fig. 150 to 152. ———? splendida
153. ———? amphora
Group 154. ———inæqualis

Group 155. Navicula ? librile
Fig. 156 to 161 (except in group 157 those figures marked with a cross) Eunotia turgida
*157. ——— Westermanni
162, 163. Cocconeis scutellum
164. Eunotia triodon
165. ———granulata
166, 167. Bacillaria paradoxa
168. ——— vulgaris
169. ——— elongata
170. ——— cuneata.
171. Fragilaria grandis
172. ——— turgidula
173, 174. ——— rhabdosoma
175. ——— bipunctata
176. ——— pectinalis
177 to 179. Meridon vernale
180 to 182. Tessella catena

PLATE IV.

Fig. 183. Isthmia enervis
Group 184. Synedra ulna
185. ——— capitata
*185. ——— lunaris
Fig. 186. Podosphenia gracilis
187 to 190. Gomphonema truncatum
191 to 193. Echinella flabellata
194 195. Cocconema lanceolatum
196 to 198. ——— cistula
199 to 202. Achnanthes brevipes
203, 204. Striatella arcuata
Fig. 205. Acineta mystacina
Group 206. Syncyclia salpa
Naunema Balticum

Fig. 208. Schizonema ? Agardhi
209. to 211. Cyclidium glaucoma
212. Pantotrichum enchelys
213. Chaetomonas globulus
214, 215. Chaetotyphla armata
216. to 218. Chaetoglena volvocina
219, 220. Peridinium tripos.
221. Michealis
Figs. 222, 223. Peridinium fusus
224. to 226. Glenodinium apiculatum
227. Trichodina tentaculata
228. to 230.———pediculus
231, 232. Urocentrum turbo
233, 234. Stentor Roeselii

PLATE V.

Figs. 253 236. Stentor caeruleus
237 to 239. Vorticella convallaria
240 to 245. Carchesium polypinum
*245 246. Epistylis ? nutans
247 248. Zoothamnium arbuscula
249 to 254. Ophrydium versatile
Group 255. Tintinnus inquilinus
256. Vaginicola decumbens

Group 257. Cothurnia imberbis
Figs. 258, 259. Enchelys pupa
260 to 265. ——— farcimen
*265. Disoma vacillans
266. Actinophrys viridis
267, 268. Trichodiscus sol
269, 270. Podophrya fixa
271 to 273. Trichoda pura

PLATE VI.

Figs. 274. 275. Lacrymaria proteus
276, 277. Leucophrys patula
278. ——— spathula
279, 280. ——— sanguinea
281. Holophrya ovum
282, 283. Prorodon teres
284 to 286. Coleps hirtus
287, 287* 288, and 289. Trachelius anas
290. ——————ovum
291 to 293. Loxodes rostrum
294. Bursaria vorticella

Fig. 295. ———leucas
296. ———pupa
*296 Spirostomum virens
297, 298.———ambignum
299. Phialina viridis
300 to 302. Glaucoma scintillans
303 to 309. Chilodon cucullulus
310, 311. Nassula elegans
312, 313. Amphileptus anser
314 to 316. ——— faciola
317 to 319. Trachelocerca olor
320. ——— biceps

PLATE VII.

Figs. 321 to 323. Aspidisca denticulata
324 to 328. Kolpoda cucullus
329 to 332. Paramecium aurelia.
333. Uroleptus musculus
334, 335. Ophryoglena acuminata
336, 337. Oxytricha gibba
338, 339. Ceratidium cuneatum
340, 341. Kerona polyporum
342. Urostyla grandis
343, 344. Stylonchia lanceolata

Figs. 345, 346. Discocephalus rotatorius
347, 348. Himantophorus charon
349. Chlamidodon mnemosyne
350 to 353. Euplotes charon
354, 355. Ptygura melicerta
356. Ichthydium podura
357, 358. Chaetonotus larus
359, 360. Glenophora trochus
361 to 364. Oecistes crystallinus
365 to 370. Conochilus volvox

PLATE VIII.

Figs. 371, 372. Micropodon clavus
373. Cyphonautes compressus
374 to 378. Megalotrocha albo flavicans
379 to 382. Tubicolaria najas
383, 283* Stephanoceros Eichhornii

Figs. 384, 385. Floscularia ornata
386, 387. Melicerta ringens
388 to 392. Limnias ceratophylli
393. Enteroplea hydatina
394. Hydatina senta
335, 396. Pleurotrocha gibba

PLATE IX.

Figs. 397, 398. Furcularia Reinhardti
399, 417. Monocerca bicornis
400, 401 and 425. Polyarthra trigla
402. Polyarthra platyptera
403. Diglena lacustris
404, 405.— grandis
406 to 408. Triarthra longiseta
Group. 490 Ratulus lunaris

Figs. 410, 411. Distemma forficula
412, 414. Triopthalmus dorsualis
415. Eosphora najas
416. Notommata copeus
418 to 420. Notommata myrmeleo
421 ——— tigris
422 Synchaeta pectinata
423, 424. Scaridium longicaudum

PLATE X.

Figs. 425* 1 6. Cycloglena lupus
427 to 429. Theorus vernalis
430 to 433. Lepadella ovalis
434 to 437. Monostyla quadridentata
438 to 440. Mastigocerca carinata
441 to 444. Euchlanis? triquetra
445, 446. ——— lynceus
447 to 453. Salpina mucronata

Figs. 454 to 456. Dinocharis pocillum
457 to 459. Monura dulcis
460 to 462. Colurus deflexus
463 to 465. Metopidia lapidella
466, 467. Stephanops lamellaris
468, 469. Squamella oblonga
470 to 473. Callidina elegans

PLATE XI.

Fig. 474. Hydrias cornigera
Group 475 Typhlina viridis
Figs. 476 to 480. Rotifer vulgaris
481 to 484. Actinurus Neptunius
485, 486. Monolabis conica
487 to 489. Philodina aculeata
490. ——— Roseola

Figs. 491 to 494. Noteus quadricornis
495 to 497. Anuraea squamula
498. ———stipitata
499 to 501. Brachionus polyacanthus
502 to 504. Pterodina patina
505. ———clypeata

PLATE XII.

Figs. 506 to 509. Pyxidicula globator
511, 515. Xanthidium? ramosum
513, 514. ——— ? difforme
512. ———hirsutum

Figs. 516 to 518. Campilodiscus? clypeus
519 to 531. Spirillum Bryozoon
532, 533. Astasia navalis
Group 534. Gyges sanguineus

PLATE XIII.

Figs. 1 and 5. Closterium Leibleinii (Ralfs.)—Fig. 1.—A frond filled with endochrome, and an empty one lying across it; the latter shows the central suture. Fig. 5—A sporangium lying between the broken conjugated, and now empty fronds.

2 and 6. Closterium striolatum (Ralfs.)—Fig 2—A frond filled with endochrome, showing the longitudinal fillets and the single row of vesicles. Fig. 6—Two empty conjugated fronds, showing the striæ, and an orbicular sporangium lying between them, enveloped in mucus.

3. Staurastrum (Desmidium, Ehr.)—eustephanum.

4. Spirotænia condensata (Ralfs)—The spiral frond or cell is seen, surrounded by a mucous hyaline sheath, and its endochrome within rolled spirally.

7. Staurastrum (Desmidium, Ehr.)—senarium.

8 and 11.—Docidium, Ehrenbergii (Ralfs)—Fig. 8. Conjugating fronds; the sporangium in an early stage of development. Fig. 11, shows the process of development by fission.

9. Docidium clavatum (Ralfs)—The granular vesicles at the extremities are well seen.

10 and 30. Euastrum pectinatum (Ralfs.)—Fig. 10. A single frond. Fig. 30. The spinous sporangium.

12 and 13. Tetmemorus Brebissonii (Ralfs.)—Fig 12, a front view; fig. 13, a side view.

14 and 15. Penium margaritaceum (Ralfs) —Fig. 14, a front view; fig. 15, a side view of two empty fronds, with their pearly-dotted surface, after the formation of the sporangium between them by their conjugation.

PLATE XIII (*continued.*)

Figs. 16 and 17. Staurastrum alternans (Ralfs)—Fig. 16, a front view; fig. 17, an end view.

18 and 23. Xanthidium cristatum (Ralfs)—Fig. 18, a front view; fig. 23, an end view.

19 and 36. Scenedesmus quadricauda (Ralfs.)—Fig. 19, a frond of two cells; fig. 36, one of four cells: the number in combination is mostly from four to eight.

20, 21, 24, 25 and 31. Staurastrum polymorphum (Ralfs.)—Fig. 20, an end view; figs. 21 and 31, front views; fig. 24, a frond, multiplying by self-division; fig, 25, a sporangium with its furcate spines or tubular processes; and around it the empty and previously-conjugated fronds.

22. Micrasterias denticulata (Ralfs.)—Its spinous sporangium; the spines bifid and trifid.

26. Cosmarium cœlatum.—Front view of frond multiplying by self-division.

27. Pediastrum (Micrasterias, Ehr.) Tetras (Ralfs.)—Front view of a frond.

28 and 29. Micrasterias oscitans (Ralfs.)—Fig. 28, a front view of frond; fig. 29, transverse view of an empty frond.

32 and 35. Hyalotheca dissiliens (Ralfs.)—Fig. 32, a transverse view with investing hyaline sheath; fig, 35, a front view, also showing the sheath.

33 and 34. Cosmarium undulatum (Ralfs.)—Fig. 33, a front view; fig. 34, its orbicular, spinous sporangium, with the empty but once conjugated frond.

37 and 40. Desmidium quadrangulatum (Ralfs.)—Fig. 37, a front view of filament, with two longitudinal waved lines; fig. 40, a transverse section, showing disposition of endochrome.

38 and 39. Didymoprium Borreri (Ralfs.)—Fig. 38, a transverse section; fig. 39, a filament, view in front,

41 and 42. Lithodesmium undulatum (Ehr.)—Fig. 41, a transverse section, fig. 42, concatenated fronds; front view.

43. Eucampia Zodiaca (Ehr.)—A filament; front view.

44. Euastrum Americanum (Ehr.)—Frond; front view.

45. Podosira moniliformis (Ehr.)—Concatenated and single fronds (frustules) attached to Polysiphonia,

46, 47, 49 and 50. Biddulphia pulchella (Ehr.)—A front view of two frustules (testules) conjoined, and also adherent by a stipes (pedicle); fig. 47, an end view; fig. 49, a lateral view.

48. Denticella Biddulphia (Ehr.)—Front view of a frustule.

PLATE XIV.

Figs. 1 to 8 inclusive. Eunotia Turgida (Thwaites.)—Fig. 1, a view of concave surface; fig. 2, a side view; fig. 3, apposition of concave surfaces in the first stage of conjugation; fig. 4, a front view of a single endochrome, showing it to have divided into two segments; fig. 5, the young sporangia lying transversely between the cleft parent frustules; fig. 6, the same, viewed end ways, showing their cylindrical figure; fig. 7, increased growth of the sporangia; fig. 8, the produced sporangia ultimately much larger than parent fronds, and now striated like the latter. At the commencement of conjugation the fronds are enveloped in mucus, as shown.

9, 10, 11, 12 and 17. Gomphonema minutissimum (Thwaites) illustrate the process of conjugation in this being, which generally resembles that in Eunotia,

11. Gallionella nummaloides (Ralfs.)—A front view of concatenated frustules, *i. e.*, of a filament.

PLATE XIV (*continued.*)

Figs. 18. Dinophysis acuta (Ehr.)—A front view.
19. Dinophysis limbata (Ehr.)—A front view.
20 and 27. Gallionella coarctata (Ehr.)—Front views.
21 and 22. Amphitetras antediluviana (Ralfs.)—Fig. 21, a single frustule; fig. 22, a chain of seven frustules, seen in front.
24 and 25. Tetracyclus lacustris (Ralfs.)—Fig. 24, front view of a filament; fig. 25, a marginal view
26. Gallionella sulcata (Ehr.)—A front view of a chain or filament.
28. Actinoptychus Jupiter (Ehr.)
29. Gallionella crenulata (Ehr.)—Front view of a chain.
30. Sphenosira Catena (Ehr.)—Front view of a chain.
31. Actinoptychus ? hexaptera (Ehr.)
32. Amphipentas ? alternans (Ehr.)
33. Asterolampra Marylandica (Ehr.)
34. Asteromphalus Humboldtii (Ehr.)
35. Heliopelta Leeuwenhoekii (Ehr.)
36. Symbolophora Trinitatis (Ehr.)
37. Spirillina vivipara (Ehr.)—A member of the family Arcellina, having a close affinity with the calcareous-shelled Polythalamia or Foraminifera.
38. Craspedodiscus elegans (Ehr.)
39 and 40. Coscinodiscus radiatus (Ehr.)—Fig. 39, a front view; fig. 40, a side view
41 and 42. Eupodiscus Germanicus (Ehr.)—Fig. 41, a front view; fig. 42, a side view. In fig. 41, the site of the three tubular processes, which led Ehrenberg at first to call it Tripodiscus, are seen.
43 and 44. Triceratium flavus (Ehr.) — Fig. 43, a front view; fig. 44, a side view.
45 and 46. Climacosphenia moniligera (Ehr.)—Fig. 45, a front view; fig. 46, a side view.
47. Terpsinöe musica (Ehr.)
48 and 49. Grammatophora gibba (Ehr.)—Fig. 48, a front view, showing the two imperfect septa (vittæ, Kutz.) at each end; fig. 49, a side view.
50 and 51. Zygoceros Surirella (Ehr.) — Fig. 50, a side view; fig. 51, a front view.
52 and 53. Grammatophora oceanica (Ehr.)—Fig. 52, a front view; fig. 53, a side view
54. Hemiaulus antarcticus (Ehr.)—A front view.

PLATE XV.

1. Amphiprora constricta (Ehr.)—A front view.
2, 3, and 4. Surirella Gemma (Ehr.)—Fig. 2, lateral aspect; fig. 3, seen on one margin; fig. 4, ventral or dorsal aspect. These figures were intended to especially represent the foot-like processes (cilia ?) and the foramina through which these are protruded.
5. Navicula fulva (Ehr.)—Ventral aspect.
6. Navicula amphirhyncus (Ehr.)—Ventral surface.
7, 8, and 9. Stauroneis phyllodes (Ehr.)—Figs. 7 and 8, ventral aspect; fig. 9, a lateral view.
10, 14, and 30. Stauroptera scalaris (Ehr).—Fig. 10, ventral surface; fig. 14, process of self-division seen on lateral aspect; fig. 30, side view of a single frustule.

PLATE XV (*continued.*)

Figs. 11. Surirella flexuosa (Ehr.)—A side view.

12, 13, 22, and 23. Surirella Campylodiscus (Ehr.)—Figs. 12 and 22, side views; fig. 23, seen on face; fig. 13, viewed lying on one end.

15 and 31. Pinnularia viridis (Ehr.)—Fig. 15, ventral surface; fig. 31, viewed laterally.

16. Stauroneis dilatata (Ehr.)—A dorsal or ventral view.

17 and 18. Stauroneis phœnicenteron (Ehr).—Fig. 17, lateral surface; fig. 18, ventral aspect.

19 and 20. Surirella Craticula (Ehr.)—Fig. 19, lateral; fig. 20, ventral surface.

21. Pinnularia Tabellaria (Ehr.)—Ventral aspect.

24 and 25. Eunotia Librile (Ehr.)—Fig. 24, ventral surface; fig. 25, front view (lateral surface.)

26. Amphora gracilis (Ehr.)—Ventral aspect.

27. Eunotia gibba (Ehr.)—Ventral surface.

28 and 53. Gomphonema apiculatum (Ehr.)—Fig. 28, a front view of two concatenated frustules; fig. 53, ventral surface.

29. Eunotia Monodon (Ehr.)—A front view.

32. Navicula affinis (Ehr.)—Ventral surface.

33. Pinnularia Chilensis (Ehr.)—Ventral surface.

34 and 36. Synedra Gallionii (Ehr.)—Fig. 34, front view of four conjoined; fig. 36, a lateral view.

35. Gomphonema Vibrio (Ehr.)—Dorsal or ventral aspect. This aspect is, strictly speaking, that of the junction-surfaces.

37. Amphora Navicularis (Ehr.)—Ventral surface.

38. Amphora Lybica (Ehr.)—Ventral surface.

39. Eunotia quinaria (Ehr.)—Viewed laterally, so that the five dentations (teeth) on the dorsum are exhibited.

40. Tabellaria lævis (Ehr.)—A front view of four conjoined.

41. Cocconeis Finnica (Ehr.)—Ventral surface.

42. Cocconeis Oceanica (Ehr.)—Dorsal surface.

43. Pinnularia Esox (Ehr.)—Ventral aspect.

44. Synedra Valens (Ehr.)—Front view.

45, 49, 50, 51 and 52. Himantidium Papilio (Ehr.)—Figs. 45 and 51, several conjoined segments viewed from above; fig. 49, a single frustule seen on ventral surface; figs. 50 and 52, end view, or a single frustule in section.

46. Cocconema Cymbiforme (Ehr.)—Ventral surface.

47. Peridinium constrictum (Ehr.)—The median sulcus or constriction is well seen dividing the lorica into two segments.—patellæ or valves, each of which is here again composed of several facettes. A distinct nucleus (sexual gland, Ehr.) is shown.

48*a*. and *b*. Cocconeis Mexicana (Ehr.)—Fig. 48 *a*, a single frustule seen on ventral surface; fig. 48 *b*, several frustules adherent to a portion of Conferva.

54. Himantidium Guianense (Ehr.)—Front view of several concatenated frustules.

55, 56 and 57. Naunema Amphioxys (Ehr.)—Fig. 55, a single frustule on dorsum; fig. 56, on its side; fig. 57, a collection enclosed in their mucous investment, seen in different positions.

58. Spherozosma? . . . (Brightwell.) — This production was found by Mr. Brightwell (see Fauna Infusoria of Norfolk.) We cannot perceive any affinity between his drawing and the members of the genus Sphœrozosma, to which he has surmised it might belong.

59. Ceratoneis Closterium (Ehr.)—Dorsal or ventral surface.

PLATE XV (*continued.*)

Figs. 60 and 61. Ceratoneis Fasciola (Ehr.)

62 and 63. Dictyocha Speculum (Ehr.)—Fig. 62, viewed in front; fig. 63, viewed sideways.

64. Difflugia acanthophora (Ehr.)—Its surface illustrates what is termed an imbricate disposition of the scale-like markings. A navicular body is represented in its interior, as seen through its transparent lorica.

65 and 66. Asplanchna Brightwellii (Brightwell.)—These two figures are from Mr. Brightwell's Book; fig. 65, is there described as "a young specimen (female), just emerged, in which the red eye and germs of other organs are seen;" in fig. 66, "may be seen the œsophagus leading to the stomach, and above the stomach two small bodies, (either salivary or hepatic glands), and under it the opaque ovisac."

67, 68 and 69. Zoothamnium arbuscula (Brightwell.)—These three figures from Mr. Brightwell, illustrate the curious cycle in development, referred to in the text,

70. Vaginicola . . ? (Brightwell.)—Apparently a Vaginicola undergoing spontaneous fission.

71. Mesocena heptagona (Ehr.)

72. Stauroptera Cardinalis (Ehr.)—A lateral view.

73. Stauroptera isostauron (Ehr.)—Dorsal or ventral aspect.

PLATE XVI.—(The figures are after Kützing.)

Figs. 1. Amphipleura pellucida
2. Amphipleura rigida
3. Denticula constricta
4. Denticula elegans
5, 6, and 7. Amphiprora (Entomoneis, Ehr.) a'ata
8. Epithemia alpestris
9. Ceratoneis spiralis
10. Cocconema gibbum
11. Gomphonema curvatum
12. Epithemia porcellus
13. (left) Podosphenia hyalina (right) P. Lyngbyei
14. Podosphenia Ehrenbergii
15. Rhiphidophora tenella
16. Licmophora divisa

Figs. 17. Rhiphidophora nubecula
18. Epithemia Musculus
19. Rhiphidophora Meneghiniana
20. Licmophora fulgens
21. Meridion Znickeni
22. Grammatophora hannulifera
23. Grammatophora constrictum
24. Odontidium mesodon
25. Odontidium turgidulum
26, Tabellaria ventricosa
27. Rhabdonema Adriaticum
28. Pododiscus Jamaicensis
29. Tabellaria flocculosa
30, 31, 32 and 32 *a*. Odontella obtusa
33. Pyxidicula adriatica

PLATE XVII—(The Figures are after Kützing.)

Figs. 1 to 12 inclusive. Fragillaria Capucina
13. Himantidium Soleirolii
14. Cymbosira Agardhii
15. Achnanthidium microcephalum

Figs. 16. Achnanthidium delicatulum
17. Cyclotella Scotica
18, 19 and 20. Cymbella gustroides
21. Doryphora Amphiceros
22. Encyonema prostratum

PLATE XVII. (*continued.*)

Figs. 23. Hyalosira rectangula
24 to 28 inclusive. Cymbella Helvetica
29. Hyalosira obtusangula
30. Sphenella augustata
31. Sphenella obtusata
32 and 33. Diadesmis confervacea
34 and 35*a* *b*. Berkeleya Adriatica
36. Gomphonema coronatum

Figs. 37 and 38*a*, *b*, *c*. Homœocladia pumila
39 to 42 inclusive, Micromega pallidum
43 to 46 inclusive. Micromega Bombycinum
47 to 49 inclusive. Homœocladia Martiana

PLATE XVIII.

Figs. 1 to 6 inclusive. Navicula (Pinnularia, Ehr.) viridis From Schleiden's Principles of Botany, to illustrate the structure of the siliceous lorica; fig. 1, anterior view (venter, Ehr.) " In the middle line are two clefts, terminating at the centre, as well as at the other ends, with a little circular enlargement, more clearly seen in figs. 3 and 5. The rounded spot in the middle, and at the two ends, is not a hole as represented by Ehrenberg. That such a hole is decidedly sometimes not present, is seen in such fragments, as figs. 3 and 5. In the position of the oblique lateral clefts, (striæ or costæ, Ehr.), the shield consists of two leaves, penetrated by the clefts, which, where both the lamellæ touch each other, are somewhat broader, which explains the varying breadth of the clefts according to the alteration of the foci. Fragments in which this structure is clearly represented, may be frequently obtained by crushing the shield (fig. 6.) Fig. 2, a lateral view, showing that the rounded enlargements of the median line are but depressions on the external surface. The double contour, denoting the thickness of the wall, is well seen. This clearly shows that a passage exists from the top to the bottom of the shield. which may be easily confirmed, if the shield, or better still an oblique section of it, be looked at from above; fig. 5 is such a section."

7 and 8. Cymatopleura elliptica (Smith.)

9. Cymatopleura solea.

10 to 19 inclusive. Closterium Ehrenbergii (Smith.)—Showing the stages in its conjugation, and the formation of the sporangia; fig. 10, a single frond in its ordinary condition; fig. 11, two fronds approaching to conjugate; fig. 12, conjugating fronds undergoing self-division, the upper showing the protuberances through the torn apices of which the contents of the divided fronds pass into the sporangia; fig. 13, shows the passage of the endochrome sac and its contents; fig. 14, conjugated fronds having perfected their sporangia; fig. 15, after M. Morren, development of the "propagules" into young fronds; figs. 16, 17, 18, 19, from Morren, development of a sporangium into a Closterium with unequal segments. The figures are all magnified 100 times.

20 to 26 inclusive. Surirella biseriata (Smith.)—To illustrate the structure and self-division of the lorica; fig. 24, side view (dorsum or venter, Ehr.); figs. 23, a front (lateral, Ehr.) view, The broad median longitudinal band is the connecting membrane of the two valves; fig. 25, an end view of fig, 24; fig. 26, transverse section of empty frustule; fig. 22, silex of connecting membrane after maceration in acid; fig. 21, apertures of costal canals seen in front; fig. 20, view of frustules on the completion of self-division.

PLATE XIX. (Rev. W. Smith.)

All the figures in this Plate are magnified 400 diameters (except fig. 2.)

Figs. 1. Pleurosigma (Navicula) formosum, average length 1-66th.
2. A piece of the same shell, magnified 5,500 diameters.
3. Pleurosigma (Navicula) speciosum
4. ——————— elongatum
5. ——————— delicatulum
6. ——————— strigosum
7, 8, 9 ——————— angulatum
10. ——————— distortum
11, 12. ——————— obscurum.

PLATE XX. (Rev. W. Smith.)

All the Figures in this Plate are magnified 400 diameters (except figs. 1, 8, and 11, which are magnified 3,200 diameters.)

Figs. 1, 2, 3. Pleurosigma (Navicula) Balticum
4. ——————— Strigilis
5. ——————— acuminatum
6. ——————— Fasciola
7. ——————— prolongatum
8. ——————— littorale
9. ——————— Hippocampus
10. ——————— young specimen
11. ——————— attenuatum
12. ——————— young specimen
13. ——————— front view showing self-division
14. ——————— lacustre
15, 16. ——————— Spencerii,
17. A piece of Shell, fig. 1
18. ——————— ,, 11
19. ——————— ,, 8

PLATE XXI.

The following figures are derived from M. Dujardin's excellent treatise, "Histoire des Infusoires."

Figs. 1. Hexamita nodulosa
2. Anthophyra Mulleri
3 and 4. Acineta tuberosa. In fig. 4 the cilia included
5. Heteromita ovata
6. Crumenula texta
7. Polyselmis viridis
8. Anisonema sulcata
9. *a. b.* Oxyrrhis marina
Figs 10. *a. b.* Ploeotia vitrea
11. Heteronema marina
12. *a. b.* Zyzoselmis nebulosa
13. Peranema globulosa
14. Cyclidium distortum
15. Cyclidium abscissum
16. *a. b.* Acomia cyclidium. Fig. *b*, self-dividing
Figs 17. *a. b.* Acomia vitrea. Fig. *b*, self-dividing
18. Gastrochæta fissa
19. *a. b.* Enchelys corrugata
20. Alysam saltans
21. *a. b.* Acineria incurvata
22. *a. b.* Diophrys marina

PLATE XXI (*continued.*)

Figs 23. Pleuronema crassa
24. *a. b.* Trachelius lamella
25. Uronema marina
26. Dileptus folium
27. Sparthidium hyalinum
28 and 29. Opalina naidum
30. *a. b. c.* Coccudina polypoda
31. *a. b. c.* Halteria grandinella
32. Loxophyllum meleagris
33. Panophrys chrysalis

PLATE XXII.

The figures in this plate are from Mr. Stein's papers in the "Archiv. für Naturgeschichte," for 1849; and are magnified 300 linear measure.

igs. 1. Vorticella microstoma. A full grown specimen exhibiting the contractile vesical, the alimentary tube, and ciliated front and mouth, also the growth of a bud from the base.

2. A specimen with the posterior circlet of cilia, prepared to detach itself from its stalk. The contractile vesicle and band-like nucleus (testes, Ehr.) are well seen.

3. An individual undergoing self-division; the nucleus has already divided; a new frontal wreath is in process of formation in the semi-lunar spaces at the anterior angle of each half,

4. A specimen in which self-division has been completed. One newly developed being has its posterior cilia produced,—its anterior wreath at the same time included, ready to detach itself.

5. *a. b. c. d. e,*; figs. *a. b. c. d.* illustrate the progress of the encysting-process. The enclosing tunic is well shown in fig. *d*, and also in fig. *e.;* in the latter this tunic is supposed to have been ruptured by pressure, and the encysted animal to have protruded itself, showing it to have not lost its original condition in its larva-like state.

6. This group illustrates the many transition-forms between the simple campanulate organisms, springing apparently from the granular matrix to which they are attached, and the larger and unmistakeable forms of Vorticella.

7, 8 and 9. Represent the encysted examples of Vorticella, and the gradual obliteration of special organs by the advance of the process; in fig. 9 all traces of organs being lost.

10. Vaginicola crystallina. A large specimen, undergoing self-division.

11. An old and young specimen in the same case: the latter with its "front" included, whilst the posterior wreath of cilia is developed to enable it to swim about. It also represents the first stage in the encysting process.

12, 13, 14 and 15. Various degrees of development of the Acineta-body of the Vaginicola; the first stage following the encysting process, is seen in fig. 12.

16. Epistylis nutans. Two large individuals supported on a stem. The one to the left with its ciliated lip protruded: that to the right, with it included. The large œsophageal cavity is well seen, with its abrupt contraction into a linear narrow intestine. The nucleus is seen lying transversely across the œsophagus, and the contractile vesicle below.

17. The Acineta-body of the Epistylis. The wavy outline indicates the contractions taking place in the integument

18. An Acineta-body of Epistylis, with the outstretched ciliary fibres or processes. Two nuclei are visible, and a large contractile vesicle.

19. Another such body, with its surface much contracted, and its contained substance wasted by the development of embryonic nuclei.

PLATE XXII (*continued.*)

20. Another figure assumed by the Acineta-body.
21. The ultimately withered state arrived at by the Acineta-body of an Epistylis, after the exhaustion of its contained formative blastema by the repeated production of embryos.

22 and 23. Very young forms (probably) of the Epistylis nutans, and apparently the Epistylis Botrytis of Ehrenberg.

PLATE XXIII.

The figures in this Plate are after those of Mr. Gosse, (Trans. of the Microscopical Society, and Annals of Natural History.)

Figs. 1. Melicerta ringens magnified 300 diameters; protruded and fully expanded; with the upper part of its tube at *a*; *b*, one of the respiratory (?) tubes. The circular disc above *b* is the pellet-cup. More in the centre are the jaws and gizzard (œsophageal head), and below portions of intestine. Fig. *c*, is a much less magnified specimen, but partially protruded from its tube, which is here shown entire.

2. Limnias ceratophylli.—The head is protruded beyond the smooth tube or sheath At *e*, is the projecting chin.
3. Notommata aurita.—Viewed laterally and contracted. It exhibits the œsophageal head and jaws, the intestine, the large ovarium, the contractile bladder below, the grape-like ganglionic mass in the head, and the tortuous vessels on each side, running the length of the body.
4. The same animal extended and rotating; the ear-like ciliated appendage, whence the specific name, is seen on each side the head.
5. Notommata aurita.—The muscular system viewed dorsally; the transverse muscles are seen as at *t*, and the longitudinal crossing them; the grape-like ganglionic mass is seen furnished with special muscles, as also the gizzard, traced in dotted outline, and the telescopic-working tail or foot. The looped band at the head indicates the tubular cavities in the head mass
6. The same animal, showing chiefly its vascular system; the large sac near the bottom of its cavity is the contractile bladder, from which proceed, on each side, convoluted tubes (tortuous vessels) furnished with tremulous respiratory tags, as near *a* and *e*.

6.* The dental apparatus of the gizzard is seen in action,

7 and 8. The male of Asplanchna priodonta.—Fig. 7, a side; fig. 8, a front view. The cavity is seen occupied chiefly by the larger testes in fig. 7; the sperm-duct is represented opening externally at the pointed base.

9. The female of Asplanchna priodonta.—At *a*, are the gill-like fissures; a large oral cavity opens into a narrow œsophagus, which ends below in a stomach. One of the strong longitudinal muscles is displayed; also tortuous vessels and ciliated tags with an ovary

10 and 11. The jaws of the Asplanchna detached.

PLATE XXIV.

Figs. 1 and 2. Discoplea atmospherica (Ehr.)

3. Discoplea Atlantica (Ehr.)
4. Discoplea sinensis (Ehr.)
5. Staurosira construens (Ehr.)

PLATE XXIV *(continued.)*

Figs. 6, 7, 8 and 9. Eunotia longicornis (Ehr.)
10. Goniothecium crenatum (Ehr.)
11. Eunotia argus (Ehr.)
12. Pinnularia (Diploneis) Didymus (Ehr.)
13. Desmogonium Guianense (Ehr.)
15. Pinnularia teniata (Ehr.)
16. Himantidium monodon (Ehr.)—Two frustules conjoined, in front view.
17. Himantidium monodon (Ehr.)—A side view, or a frustule seen in section; having but one elevation on its upper margin (dorsum, Ehr.) it derived its specific name
18, 19, 20 and 21. Arachnoidiscus Japonicus (Shadbolt)—Fig. 18, external membrane, as seen when detached from the inner framework, or when viewed from the outside of the shell as an opaque object; 19, the inner framework is exhibited on a black disk as an opaque object; 20, the membrane and framework united, as seen by transmitted light, 200 linear; fig. 21, the same, more amplified, 500 linear
22 and 23. Campylodiscus parvulus (Smith.)—Fig. 22, a disc of valve; fig. 23, view presenting the connecting membrane, and valvular ridges
24 and 25. Grammonema Jurgensii (Ralfs)—Fig. 24, a front and lateral view of a single frustule; fig. 25, a band of concatenated frustules
26 and 27. Gallionella (Nageli)—A series of figures to illustrate the distribution of the chlorophylle (endochrome), and the presence of a nucleus; fig. 26 *a*, viewed from the base; *b*, from the lateral surface. Two bands of chlorophylle are seen on each side, and their section at the angles; *c*, from the base; fig. 27 *a*, seen from below. Nucleus with nucleoli and sap currents; large and small chlorophylle globules; *b*, seen from the side. The two lateral bands of chlorophylle are seen, and a parietal nucleus with sap-currents from it, in the centre of one side; *c*, an individual after division, seen from the side. The chlorophylle band appear only in section. Each secoudary cell has a parietal nucleus
28 *a. b. c. d.* Bacillaria (Nageli.) Fig. *a.* viewed from the broad side. A granular nucleus in the centre; fig. *b.* also the broad side; an individual before division. The nucleus primarily divided; fig. *c*, division complete; fig. *d.* viewed from the base (in section.)
29. *a. b. c. d.* Orthoseira Dickieii (Thwaites); fig. *a.* filament, in ordinary state; fig. *b.* filament, the terminal cells of which are becoming converted into sporangia; fig. *c.* sporangia; fig. *d.* sporangial frustules becoming developed from one of the halves of a previously divided Sporangium. (magnified 220 linear.)
30. *a. b.* Dickieia Danseii (Thwaites); fig. *a.* portion of frond (thirty-five linear); fig. *b.* a part of some magnified 220 linear. In it two frustules are shown; one in front, the other on side aspect. Mr. Ralfs has subsequently shown this to be one of the Algæ, not of the Diatomeæ; not a Dickieia.
31. *a. b. c. d. e.* Dickieia ulvoides (Ralfs). Group *a.* Natural size in different stages of growth; fig. *b.* frustules (navicular-bodies) highly magnified, when fresh; fig. *c.* one when dried; fig. *d.* a lateral view of the same; (group *e.* a portion of frond, less magnified), showing the simple and binate frustules.
32. Meloseira varians (Thwaites), Gallionella, Ehr.) Filament with sporangia (220 linear.)
33. Aulacoseira crenulata (Thwaites.)—Filament with sporangia (220 linear)
34. Dictyocha Tibula (Ehr)
35. Dictyocha trifenestrata (Ehr)

INDEX

TO THE

DESCRIPTIONS OF THE FAMILIES & GENERA OF INFUSORIAL ANIMALCULES

DESCRIBED IN PART III.

NOTE.—*The names of Families are printed in Italics.*

S. Straker, 80, Bishopsgate Street Within.

ERRATA.

—o—

Page	Line	For		Read
104	6	M. Natchet	...	M. Nachet.
145	31	PROGNOCENTRUM	...	PROROCENTRUM.
146	18	LAGENELLA	...	LAGENELLO.
193	10	CHLOROGONIUM	...	COLACIUM.
220	6	*Flagilaria*	...	*Fragilaria.*
243	17	*unindentata*	...	*unidentata.*

389, insert Genus LIOSTEPHANIA from page 492.

469, insert three genera as named at page 490.

529, 530 and 531 *for* VORTICELLINA *read* VORTICELLA.

647 *line* 7 *for* CYCLOGENA *read* CYCLOGLENA.

The Appendix mentioned at page 92, will be included in a supplement and published separately.

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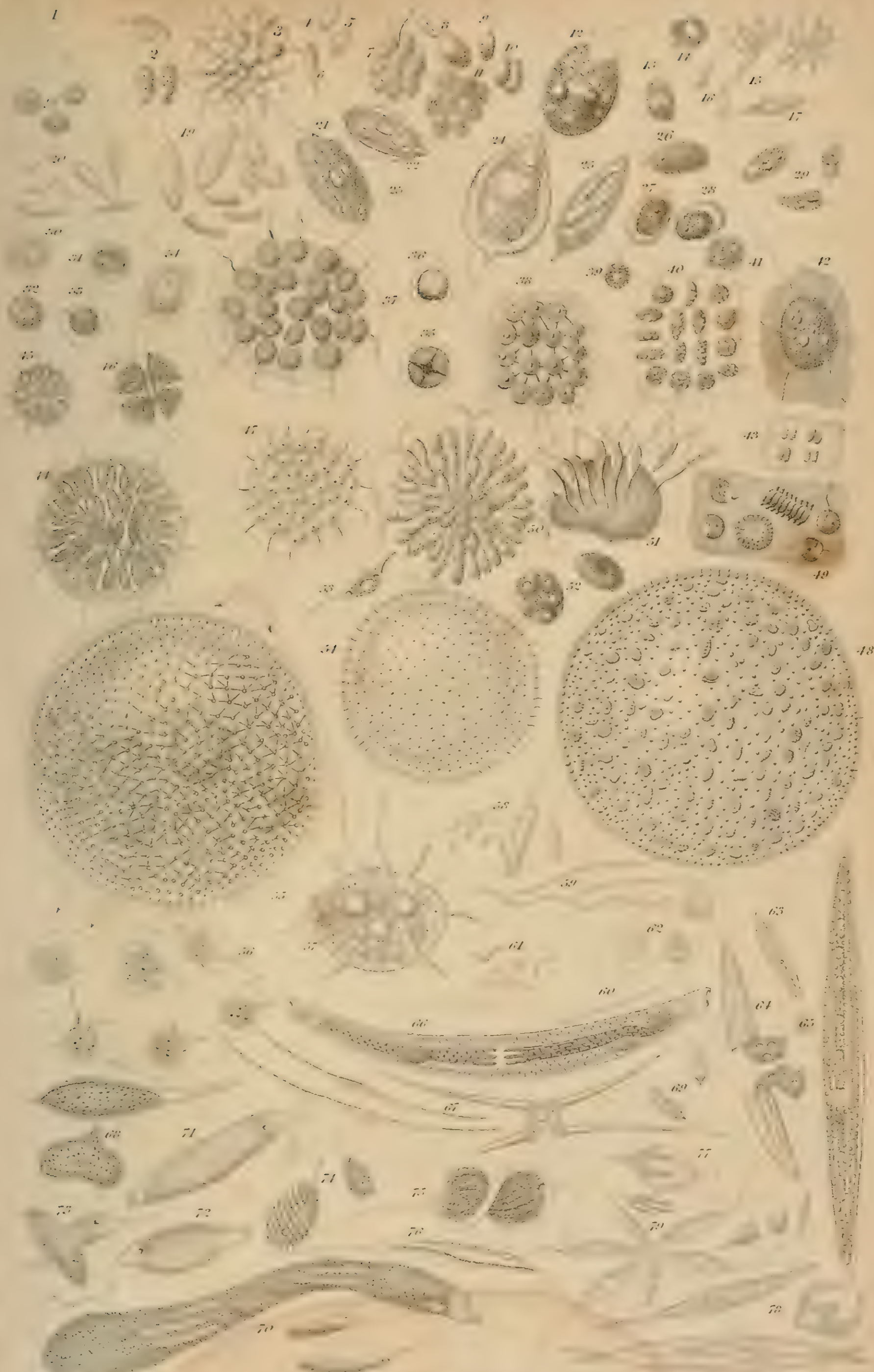

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J. Cleghorn sc.

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Andrew Pritchard. May 1.1841.

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Andrew Pritchard. 1 August 1841.

A Pritchard April 1841.
W K.

A. Pritchard, April. 1841.
W. K.

A Pritchard, June 1841

A. Pritchard June 1841.

J. Bauer & F.W. ... del. A. Pritchard June 1841 T. Kelsall sc.

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April. 1852. Andrew Pritchard. John Cleghorn.

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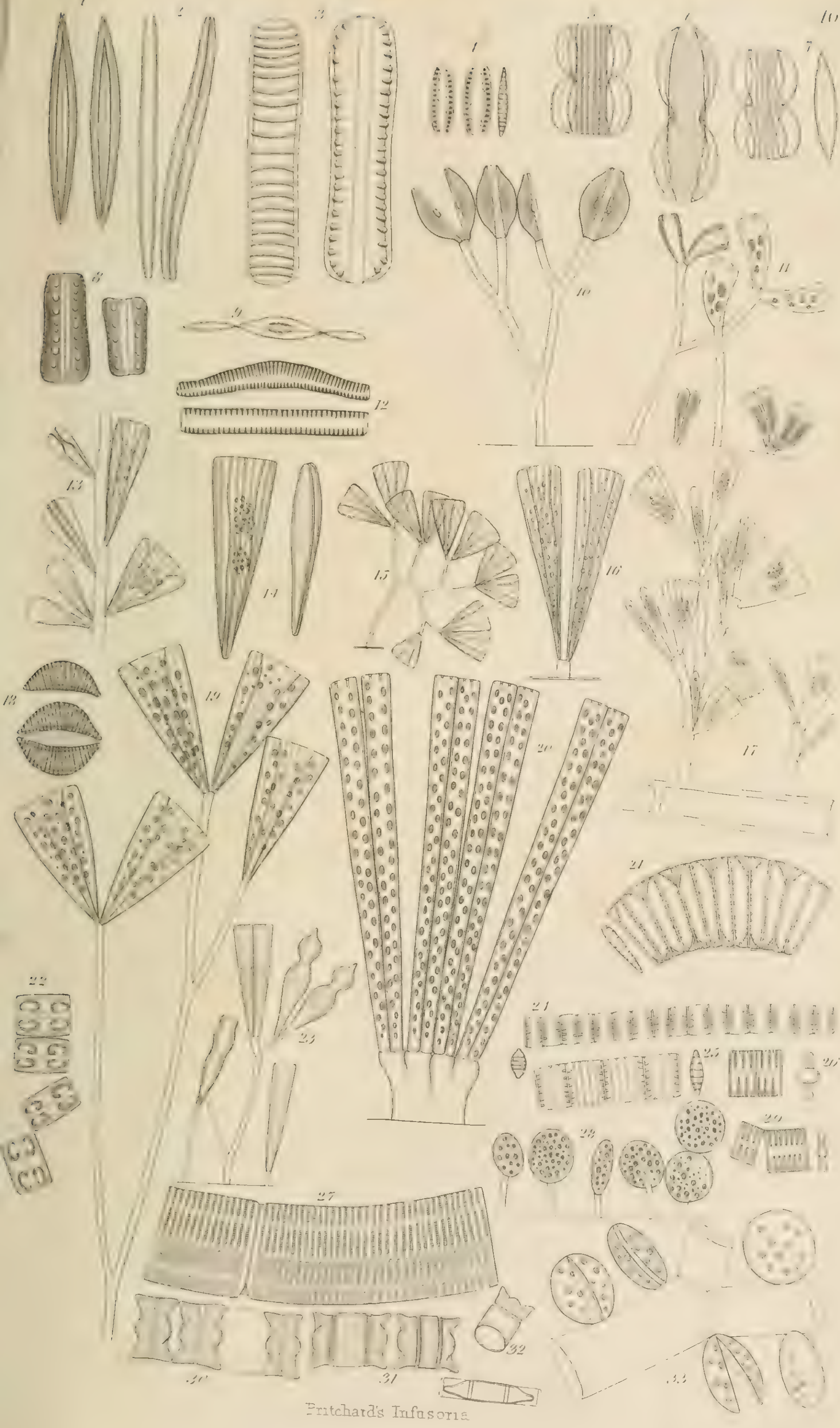
John Cleghorn.



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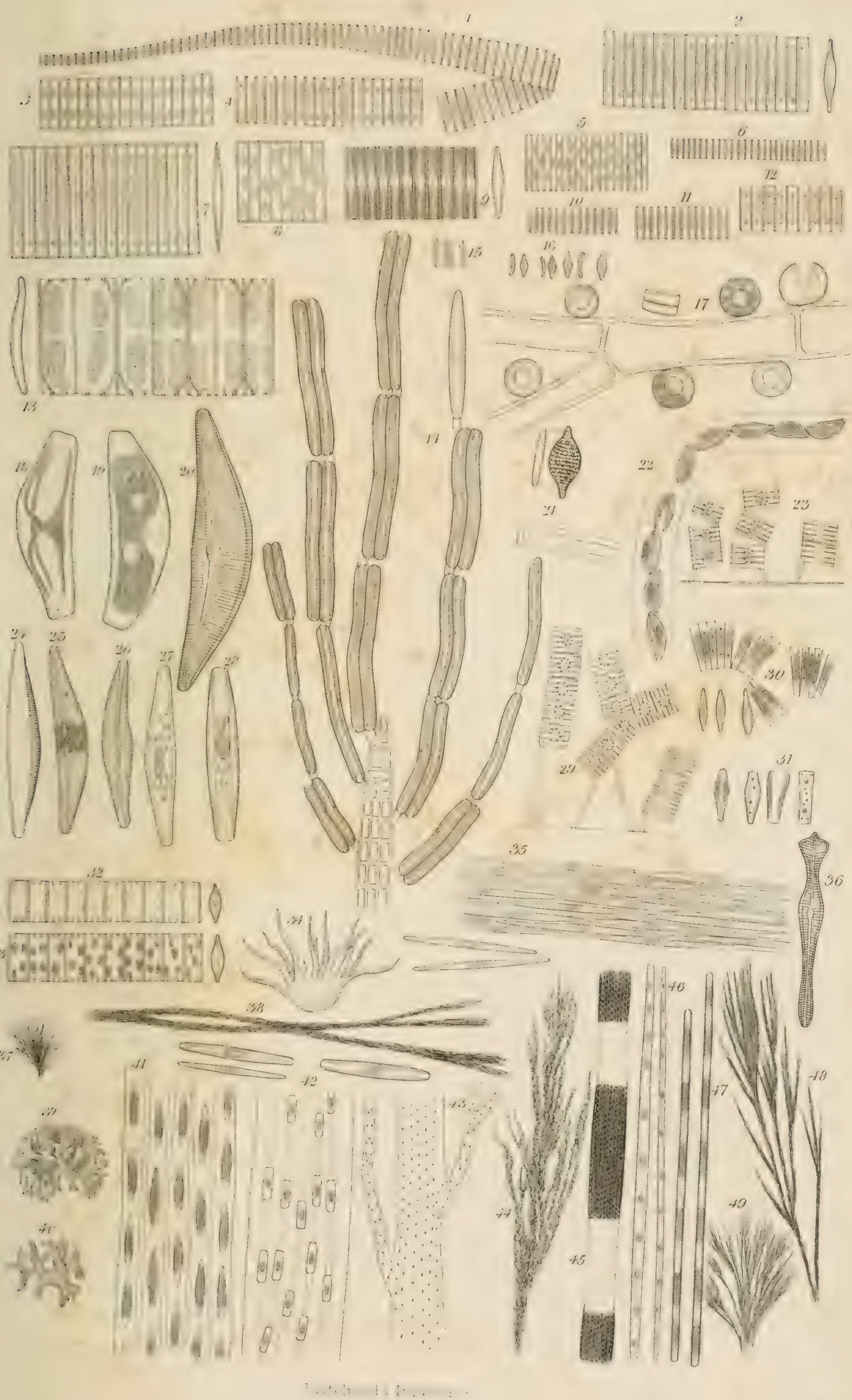
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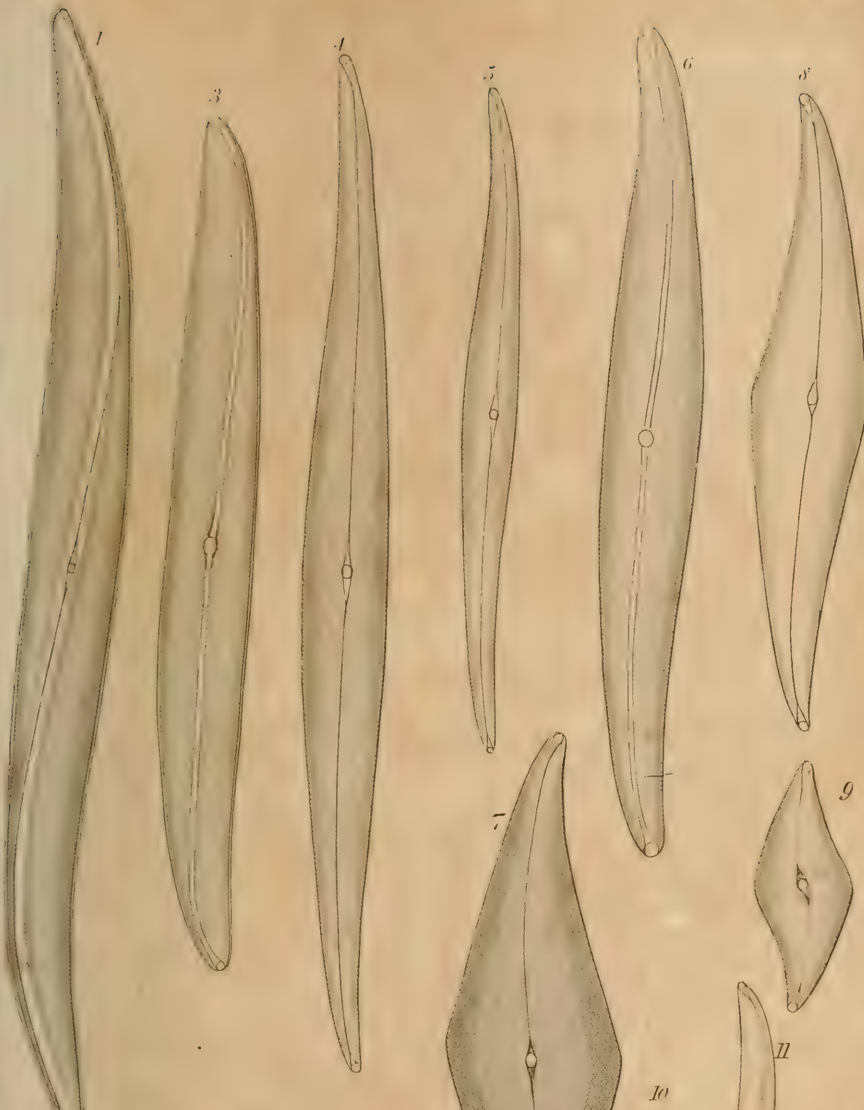

W Smith del

Pritchard's Infusoria

J. De C. Sowerby sc.

Rev.d W. Smith del. Pritchard's Infusoria J. De C. Sowerby sc.

Pritchard's Infusoria.

May 1852

J Skury Sc

Pritchard's Infusoria

May. 1852

J. Shorr

Pritchard's Infusoria